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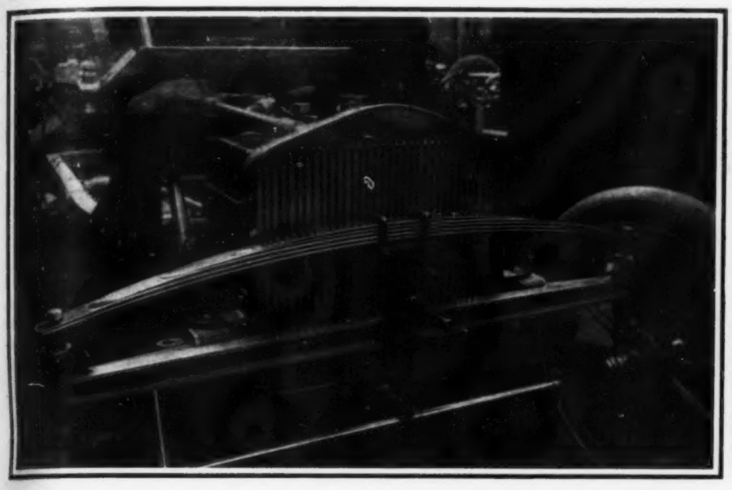
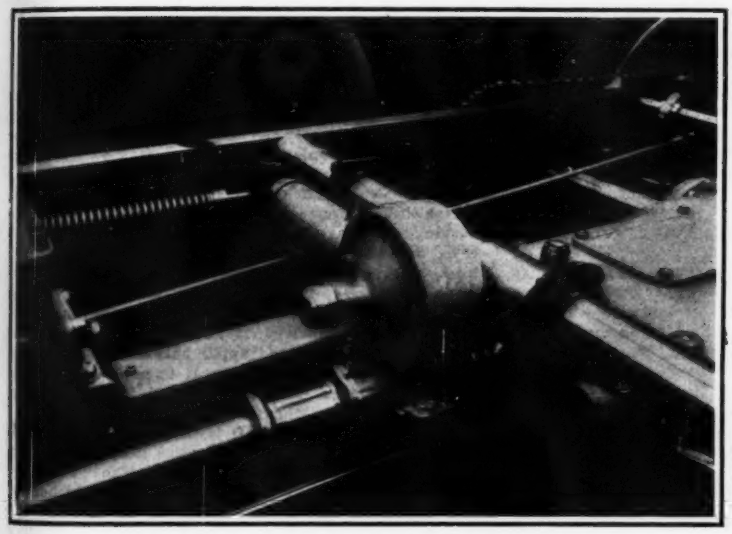


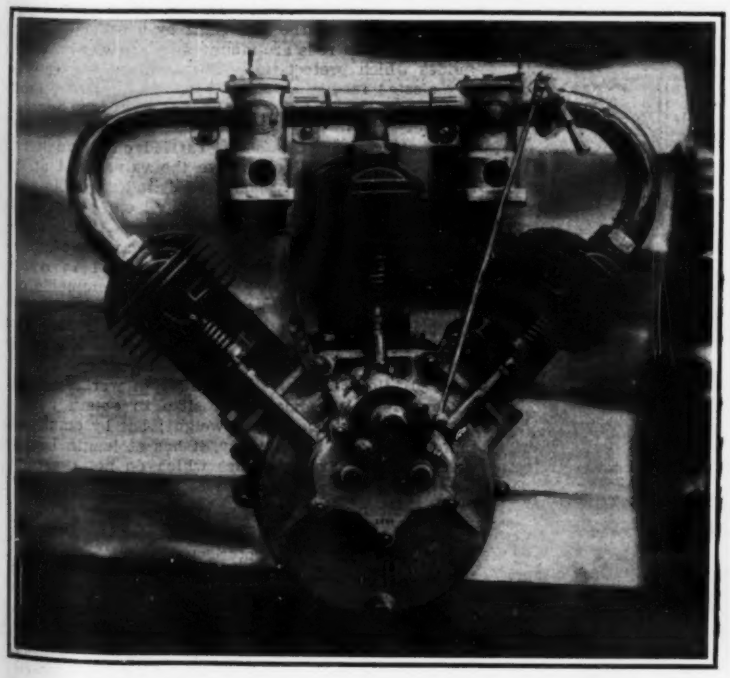
RUNABOUT HAVING FINLESS TUBULAR RADIATOR AND PECULIAR SUSPENSION.

THE MENDELSSOHN LIGHT, HIGH-POWERED RACER.



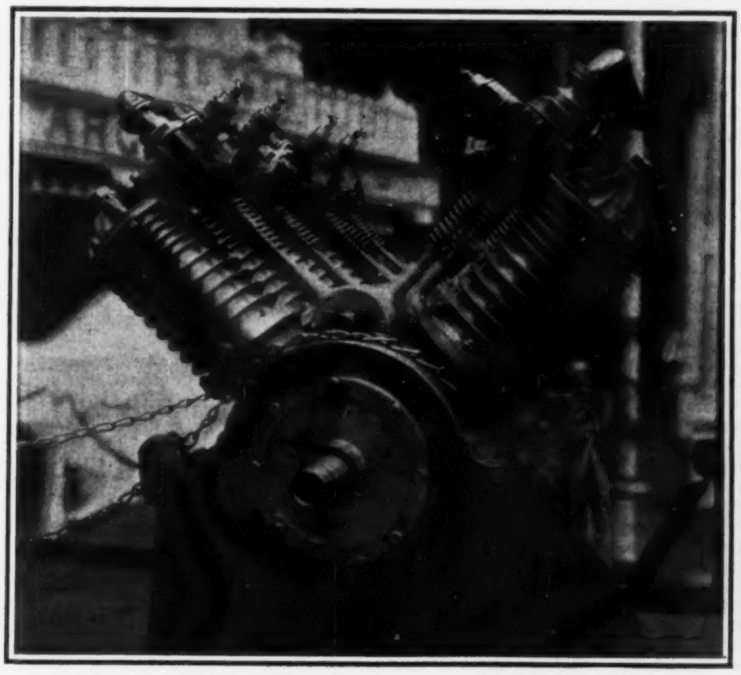
POWER-DRIVEN AIR PUMP FOR INFLATING TIRES.

MOTOR BICYCLE ENGINE DRIVING THE REAR WHEEL DIRECT THROUGH SPUR GEARS.



15-HORSE-POWER, 3-CYLINDER, AIR-COOLED BUCHET MOTOR WEIGHING COMPLETE 61.6 POUNDS.

Note the slotted bands around cylinders near their bases for the auxiliary exhausts.



30-HORSE-POWER, 8-CYLINDER BUCHET AIRSHIP MOTOR WEIGHING 99 POUNDS COMPLETE.

The cylinders of this motor are 2.952 inches bore, and the pistons have a stroke of 3.937 inches. The motor develops 33 horse-power, 2 of which is used in driving a fan.

MOTORS, ACCESSORIES, AND LIGHT CARS EXHIBITED AT THE PARIS SHOW.

NOVELTIES AT THE PARIS AUTOMOBILE SHOW.

A DIRECT SPUR-GEAR DRIVE FOR MOTOR BICYCLES.

THE new form of motor-cycle drive which has been designed by G. Knap, of Troyes, is intended to supply a practical touring machine, either in the form of a motor bicycle or tricycle, equipped with a specially small and light motor. The constructor claims to have made a great improvement in the driving mechanism. Instead of placing the motor at the center of the bicycle and using a chain or belt drive to the rear wheel, he mounts the motor directly against the rear axle, placing it on the outside of the wheel and causing it to drive the latter by means of a small pinion on the motor shaft and a large gear which is fixed to the wheel.

This method was adopted after trying all the usual forms of transmission from motor to rear wheel, such as universally-jointed shafts, chains, or belts. When using a chain drive it was found that the shocks which were produced by the chain made it necessary to provide a friction clutch, and as the latter must necessarily be of small size for use upon a motor cycle, it gave a great loss of power from slipping, and consequently no advantage over the belt drive in this respect. As three-quarters of the power of the motor was lost by the slipping of the clutch, a motor of 2¾ to 3 horse-power fitted with a clutch of large diameter was found necessary. Shaft drive has the same disadvantages as regards the clutch, and also gives an added friction from the bearings which are needed. The latter is specially noticeable at high speed. There is also more mechanism to look after, and an increased weight.

With the use of a direct drive from the motor placed beside the rear wheel, many of the above difficulties were avoided, and it was found that the size of the motor could be at once cut down from 2½ horse-power to a small 1¼-horse-power type, which was quite sufficient for touring purposes. The most favorable conditions for steadiness are obtained, as the motor is as low down as possible and is placed well at the rear of the machine. An objection may be made that the motor lies on one side of the wheel and is out of the center, but the displacement of weight is in reality very small, and the rider can easily correct it with a very slight inclination of the body. This may be proved by attaching an equal weight to a bicycle, when no inconvenience is felt.

This form of drive is used not only on motor bicycles, but on tricycles and tri-cars as well. No matter what form of machine it is used upon, a decided gain in efficiency will result. The coiled springs shown within the large gear ring transmit the power to the wheel and absorb the shock due to the impulses of the motor.

MOTOR-DRIVEN AIR PUMP FOR INFLATING TIRES.

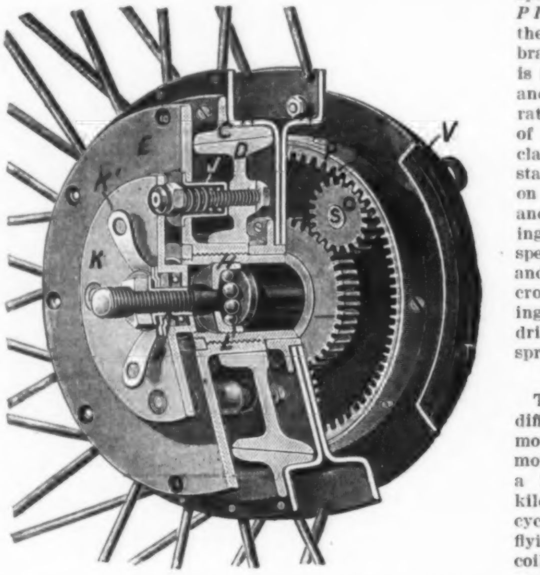
The Léon Bollée firm had one of the most attractive displays which were to be seen at the show, and exhibited a number of their standard cars and chassis. As the main features of the Bollée car do not present any very striking modification over last year's type, except in the way of general improvements, we will only describe a very ingenious little device which this company has brought out this year and which is shown mounted upon one of their chassis. It consists of an air-pump by which the tires of the car can be inflated in a short time. The advantages of such an arrangement will be appreciated by all who have had to do with the usual form of hand pump, as it gives a great saving of time and also of labor. The pump is of small size. The mechanism by which it is driven from the motor is completely inclosed. It is placed about midway on the chassis between the motor and the transmission, being mounted on the shaft which connects these two parts, and driven from this shaft by a set of gears. The pump can be driven at any desired speed by varying the speed of the motor. In general, a pneumatic tire of the usual kind can be inflated in about two minutes. There is no danger of carrying the air pressure beyond the proper limit and causing the tire to burst, as the nozzle with which the rubber hose is attached to the tire carries a special form of safety valve, so that the air pressure is not allowed to go beyond 75 pounds per square inch.

AN ADJUSTABLE SAFETY AIR VALVE FOR PNEUMATIC TIRES.

A simple device which is likely to prove very useful in connection with pneumatic tires has been invented by M. Camille Vadon, of Lyons. When a tire is filled with cool air at a pressure of 50 or 60 pounds per square inch before starting the car, it often happens that the heat of the road may increase the pressure greatly, even to 80 or 90 pounds and the tire is likely to burst if it is not very strong. The new device overcomes this difficulty. It is a new form of valve known as the valve-eclair, and it fulfills three different purposes. First it allows the tire to be pumped up in the usual manner. Second, it gives the chauffeur an indication of the exact pressure at which the tire is working, and, by a screw adjustment, this pressure can be fixed in advance so that the tire cannot be inflated beyond this point. Third, on the road it acts to prevent the pressure from rising beyond the desired point under the influence of heat. In the lower part of the tire valve is placed a second valve which allows the air to escape when need be. This valve works against a spring and the latter is adjusted by a nut so as to quickly release the air pressure of the tire at any desired point. In the upper part of the device is a piece which moves up or down as the screw is adjusted; and as this piece carries a set of graduations with the figures for the pressures, the chauffeur can set it for the pressure he wishes to keep in the tire, and then pump up the tire as usual, when the escape-valve will prevent over-pumping beyond the right amount. On the road, should the heat tend to cause the air to expand and increase the pressure, the escape-valve comes into play and relieves the tire, bringing the pressure down to the proper point.

HUB WITH TWO-SPEED GEAR FOR MOTOR BICYCLES.

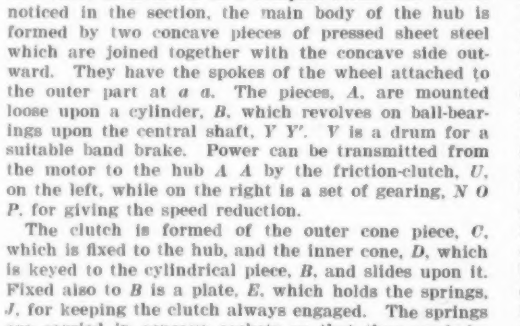
A form of hub having a speed-reducing mechanism making it applicable to motor cycles and the like, is



THE RIVIERE HUB BROKEN AWAY, SHOWING CLUTCH AND PLANETARY GEAR.

illustrated herewith. The hub also contains a friction clutch for locking it to the axle for direct drive, and the whole is mounted in a compact form. As will be noticed in the section, the main body of the hub is formed by two concave pieces of pressed sheet steel which are joined together with the concave side outward. They have the spokes of the wheel attached to the outer part at *a a*. The pieces, *A*, are mounted loose upon a cylinder, *B*, which revolves on ball-bearings upon the central shaft, *Y Y'*. *V* is a drum for a suitable band brake. Power can be transmitted from the motor to the hub *A A* by the friction-clutch, *U*, on the left, while on the right is a set of gearing, *N O P*, for giving the speed reduction.

The clutch is formed of the outer cone piece, *C*, which is fixed to the hub, and the inner cone, *D*, which is keyed to the cylindrical piece, *B*, and slides upon it. Fixed also to *B* is a plate, *E*, which holds the springs, *J*, for keeping the clutch always engaged. The springs are carried in concave sockets so that they work by compression. At the inner end they press against the end of the socket and at the outer end against a thrust ring, *W*, which carries the outer ends of the studs around which the springs are coiled. The ring, *W*, is mounted loose on the main shaft at *L* by means of a ball bearing. To release the clutch by pushing *C* and



CROSS-SECTION OF THE RIVIERE TWO-SPEED HUB.

A NOVEL HUB FOR MOTOR CYCLES.

D apart against the spring action the following simple device is used. The flanged sleeve, *M*, fixed on the shaft, serves to hold the disks *K* and *Z* together. These two pieces are concave and have a set of depressions which fit into each other and cause them to lie close together; but should one of them be shifted around, the disks are forced apart. The shifting is obtained by the lever, *K'*, which the driver works by a rod. Pulling on the rod forces the disks *K* and *Z* apart. As *M* is fixed, *Z* presses against *L* or *W* and forces the clutch apart.

The other side of the hub contains the device for reducing the speed by a set of planetary gears, so as to obtain one-third the speed had when the clutch is in. On the central piece, *B*, is fixed a gear ring, *N*. This meshes with the planetary gear, *O*, which is mounted on stud, *S*, carried in the hub. *O* meshes with the internal gear ring, *P*, which is carried in the concave piece, *P'*, the latter being connected by *q* with the brake drum, *V*. All the gears of this mechanism are free except the pinion, *N*. Let us suppose the clutch to be out. When the main sleeve (upon which sprocket, *R*, is mounted) revolves, the pinion, *N*, causes *P P' p V* to turn loosely, while the hub *A* is stationary, the machine being at rest. Upon applying a steel band brake to *V*, the internal gear, *P*, is held, and thus *N* is made to drive the planetary gears about in a circle, and with them the hub, *A*, and the wheel. The gear ratio is such that *A* now turns at one-third the speed of the main shaft. The following advantages are claimed for the new device. First, the motor can be started when the wheel is at rest, by simply pressing on a pedal. Second, the machine can be started easily and gradually, even on an up-grade, without its having to be pushed. Third, direct drive on the high speed is had, as usual with almost all automobiles and motor cycles. Fourth, the bicycle can circulate in crowded places like an automobile, stopping and starting while the motor continues to run. The hub is driven from the motor by a chain running on the sprocket, *R*.

LIGHT-WEIGHT FLYING MACHINE MOTORS.

The Buchet firm has recently brought out several different types of light-weight, high horse-power motors for bicycles and flying machines. Two of these motors are illustrated on our front page. These are a 15-horse-power, three-cylinder motor weighing 28 kilogrammes and being intended for racing motor cycles; and a 30-horse-power eight-cylinder motor for flying machines, which weighs complete with spark coil, batteries, and cooling apparatus, only 45 kilogrammes. This motor has been simplified as much as possible, and in place of water-cooled cylinders, flanged air-cooled cylinders are used. A cast aluminium fan fastened upon the crankshaft directs a stream of air through eight pipes upon the valves in the cylinder heads. About two horse-power is absorbed by this fan; but, as the motor develops a total of 33 horse-power, there is 31 horse-power available for the propellers of the flying machine. The cylinders are of cast steel having a high resistance. The flanges which surround them give them great rigidity. They are attached to the crank case by bolts and flanges. The crank case is of nickel steel reinforced in the upper half in order to avoid any deformation. All joints are welded. As a closed crank case is employed, splash lubrication is made use of. There are three bearings in the crank case, two of which are lubricated by ring oilers, while the third, which is the middle bearing, is in two pieces. The crank bearings can be readily adjusted through hand holes in the bottom of the crank case, while the whole crankshaft can be readily removed, if necessary, since the bearings are attached to the upper half of the case. The crankshaft is of nickel steel. It is made hollow, and the crank cheeks have been shaped in an I section in order to obtain the maximum resistance with the least weight. The camshaft is in a single piece and is made hollow. The two-to-one gears have a very thin web pierced with numerous holes. The connecting rods are also of nickel steel, turned and made hollow. The heads of the rods are grooved to increase the strength. The pistons are of special steel. They carry three bronze rings each.

The exhaust valves are also of special steel, and are operated from the cam shaft by a roller and push rod. The push rods are mounted in special aluminium guides which protect them and keep the oil from being ejected from the crank case. The cylinder heads are of cast-steel having a high resistance. They contain suitable valve chambers in which are valves and spark plugs. The exhaust is carried off through two separate passages placed above the valves and at the side of each of the two sets of cylinders. The inlet valves are automatic. Their pipes all end at a central point at which is placed the carbureter. All the different apparatus needed about the motor is made of aluminium. The motor is completely inclosed in a fine metallic network, so as to keep any inflammable gas in the balloon from igniting. This network acts after the principle of the miner's lamp. The Buchet firm is also about to bring out a 60-horse-power engine on similar lines, and which, it is claimed, will not weigh over 80 kilogrammes (176 pounds) in working order.

Heretofore it seemed impossible to obtain such a high power with such light weight; but by employing materials of the best quality, it has at length become possible to construct engines which do not exceed in weight more than 2½ pounds to the horse-power.

LOW-PRICED VOITURETTES AND SPEED CARS OF NOVEL CONSTRUCTION.

While the trend of motor-car manufacture in this country during the past year has been toward the development of the high-priced touring car, in France just the opposite has taken place, and many of the established touring-car manufacturers have brought out small, light, low-priced runabouts for business and pleasure purposes. One of the most novel of these, and one, too, of rather freakish appearance, was exhibited by Messrs. Sizaire and Naudin at the recent Paris Show. This car has received a thorough road testing, and appears to fill the bill very nicely for one who wants a light car cheap to maintain and to run.

In the matter of construction, novelty is first seen in the frame, which consists of two wood sills of strong section. These are not armored, but they are strong enough to withstand all stresses to which they are subjected. These two side bars are curved inward at the front in the same manner as is the usual pressed-steel frame. They are tied together by tubular steel cross bars at the front, while the body itself forms the cross member toward the rear. The sills extend back over the rear axle, but have no cross connection at the rear end. Each one is supported by a single, forwardly-extending, curved spring placed outside of the sill and having its forward end attached to it, while the rear end is mounted upon a shackle on the rear axle.

A single-cylinder, vertical motor is supported by its lugs upon the cambered frame at the front. This motor develops 7 horse-power at 1,400 R. P. M. It is fitted with mechanically-operated valves, the inlet valve being placed above the exhaust valve and operated by a tappet. It also has an automatic spark advance, maintained by sliding the igniter cam by means of a centrifugal governor. Under favorable conditions this motor can be accelerated so as to give 9 to 10 horse-power. It is fitted with an automatic carbureter, and a very efficient muffler. A radiator consisting of a set of vertical tubes without fins is another distinctive feature. This, as well as the peculiar front suspension, is to be noted in our photograph. A small water tank is fitted on top of the dashboard. So good is the efficiency of this radiator, which consists of a cast bronze frame, whose top and bottom parts are connected by small copper tubes of 58 gage, that in a 12-mile climb up Mt. Ventoux, no loss of water took place. The gasoline tank is placed between the motor and the radiator, and supplies the carbureter through a short pipe by gravity. The battery and coil are contained in a wooden box beside the fuel tank, and as a consequence the wires leading to the motor are very short. An automatic oiler is placed on the crank case of the motor. The motor itself is placed just in front of the dashboard, and so close to it that the flywheel is at the rear of the dash. A straight propeller shaft runs from the clutch (which is a metal disk held in contact with the full web of the flywheel by means of a strong spring) to the rear axle, where a three-speed transmission of novel construction is located in the differential casing.

In place of the usual bevel gear there is a large disk having a set of spur teeth on one side at the periphery. The extension of the propeller shaft carries three sliding pinions very much like an ordinary spur gear in appearance. By means of an eccentric these pinions are first moved sideways out of mesh with the gear, and then slid longitudinally of the car until the proper one is opposite the teeth of this gear. The eccentric then moves this pinion into mesh, face on. This method of changing gears is an adaptation of the Renault scheme, first brought out a couple of years ago. In this instance it makes possible the obtaining of a direct drive on all three speeds forward. The small size of the gears is remarkable, the smallest pinion being only 35 millimeters (less than 1½ inches) in diameter, while the high-speed gear is 100 millimeters (about 4 inches). The car will travel from 30 to 35 miles an hour on the high speed. It is fitted, among other things, with an irreversible steering gear.

The most striking feature of the car is undoubtedly the absence of a front axle, and the consequent suspension of the front rim from an I-section steel forging placed at the base of the radiator and hung from an arched front spring connecting the top ends of the two long, vertical, steering pivots. These long spindles play up and down in suitable sockets on the end of the I-beam mentioned. The considerable distance between the hub axis and these sockets would seem to make a very weak wheel support. The construction, while perhaps somewhat simpler than the usual form, does not appeal to the engineer as being at all substantial. It is said, however, to have withstood successfully all the tests which have been given it. It is certainly a distinctive feature of this light small car.

Another peculiar light car is the Mendelssohn 4-cylinder speedster shown on our front page. This car is a racer pure and simple, and it is fitted with only such parts as are absolutely essential. The gasoline tank is on one side of the engine and the water tank on the other. Both are made cylindrical with conical ends. The car, as can be seen, is made up chiefly of the motor which is mounted on a square frame carried on two long springs. The motor drives the rear axle through uninclosed bevel gears. There is no transmission gear, a simple clutch in the flywheel being all that is needed. The seat is mounted on inclined tubes extending back from the center of the car. A bevel gear steering arrangement is fitted. The valves are fitted in the cylinder heads and operated by tappets from a special inclosed camshaft. This camshaft is on the opposite side of the motor to that shown in the picture.

MAGNETIC ALLOYS.

The London Electrician states that B. V. Hill has made some further discoveries in connection with the magnetic alloys of non-magnetic metals discovered by Heusler. He finds that they show an irreversibility with regard to high temperatures, just as the nickel steels show an irreversibility with regard to low temperatures. He worked with an alloy containing 60 per cent copper, 25 per cent manganese, and 15 per cent aluminium, and with another alloy containing more aluminium. The latter showed an induction of B = 5,750 C. G. S. in a field where H = 87 C. G. S., with a comparatively large hysteresis. It was then subjected to repeated heating and cooling.

Starting with a magnetic intensity of 311 units, the curve fell till it reached the axis at 320 deg. On cooling, the magnetization was found to be only 267 units. On heating again, the magnetization did not disappear completely, but remained as high as 7 units up to 500 deg. On cooling, it appeared much diminished, being only 27 units at ordinary temperatures, and 36 units at the temperature of liquid air. Mr. Hill attempted to restore the magnetization by heating to dull redness, but only attained an intensity of 90 units. Heating to a bright red made this 155 units; and subsequent exposure to liquid air, 165 units. The other alloy, heated to 950 deg., lost its magnetism permanently and became 14 per cent lighter. The nickel steels are heavier in the non-magnetic state.

STATISTICS REGARDING AUTOMOBILE CONSTRUCTION OBTAINED AT THE RECENT PARIS SHOW.

At the Paris Automobile Show held in the Grand Palais last December, fifty-five French constructors exhibited 326 touring cars and chassis. Of this number, 148 were complete vehicles, and 178 were merely chassis. The 326 vehicles represent 150 different types, and the classification given below will show the percentage of machines of low, medium, and higher horse-power which were exhibited at the last two shows.

	1904. Per cent.	1905. Per cent.
6-horse-power chassis	3	2
8-9-horse-power chassis	17	6
10-12-horse-power chassis	12	15
14-16-horse-power chassis	23	19
18-22-horse-power chassis	16	13
24-30-horse-power chassis	20	27
Chassis above 35-horse-power	8	18

From the above it will be seen that the 24-30-horse-power is the standard power for 1906 in place of the 14-16, which was the standard for 1905.

Regarding the matter of price, the cheapest chassis was the 8-9 horse-power type, which sold for $395. From this up the prices ranged to 50,000 francs ($10,000), which was the sum asked for an 80-horse-power chassis. The price per horse-power has diminished from 716 francs ($143) last year to 631 ($126) this year. This is a favorable feature for the purchaser, and is one which is scarcely noticeable in America, although the price here is, on the average, only about $100 per horse-power.

Regarding motors, the table below shows the different percentages for the last four years; and it is interesting to note that the proportion of 4-cylinder motors has diminished slightly during the past year.

	1902. Per cent.	1903. Per cent.	1904. Per cent.	1905. Per cent.
1-cylinder	12	15	6	8
2-cylinder	37	26	15	20
4-cylinder	48	55	76	71
Divers types	2	4	2	1
Automatic inlet valves	55	33	3	6
Mechanically - operated valves	45	67	97	94

The motors noted in "divers types" are 3 and 6-cylinder engines, and those having horizontal and inclined cylinders. It is noteworthy that the mechanically-operated inlet valve has also fallen off slightly in the number of its users during the past year.

Single-cylinder motors are a little more numerous than during the preceding year. Not only are there a greater number of types of single-cylinder engines, but the small engines of the large firms have been applied to a considerable number of small vehicles.

Regarding the construction of the motor in the matter of cylinders being cast separately, or in pairs, there should also be added the latest practice of casting all four cylinders in a single block, which was one of the novelties at the recent show.

	1904. Per cent.	1905. Per cent.
Separate cylinders	35	33
Cylinders in pairs	65	63
Cylinders *en bloc*	0	4

It is also interesting to note the arrangements generally adopted for operating the inlet valves. These are operated either from the same side of the cylinders as the exhaust valves by means of a single cam shaft, or they are placed on the opposite side of the cylinders and are driven from a separate cam shaft. Still another arrangement for operating these valves from a single cam shaft is by means of bell cranks placed above the heads.

	1904. Per cent.	1905. Per cent.
Valves operated from one side	24	28
Valves operated on opposite sides	66	64
Valves operated from above	7	8

It can be seen from the above table that the changes in valve operation are slight.

Another comparison of interest is that of the various forms of ignition used during the past four years.

	1902. Per cent.	1903. Per cent.	1904. Per cent.	1905. Per cent.
Low-tension magnetos	22	22	26	39
High-tension magnetos	..	6	23	45
Magnetos, with electro-magnetic low-tension plugs	..	..	..	5
Storage batteries	74	72	49	11

These figures show the constant increase in high-tension magnetos. Notice should also be taken of the new magnetic plugs, which receive a low-tension current and transform it at the time of break. Some electricians claim that this is the coming form of ignition. Ignition by batteries and coil has dropped off greatly during the last year. There was a total of thirty-six machines furnished with double ignition. This was a slight increase over those shown the preceding year.

The next table shows the various systems of cooling employed on 1904 and 1905 cars.

	1904. Per cent.	1905. Per cent.
Thermo-siphon	14	12
Centrifugal pump	70	67
Other pumps	16	21

It will thus be seen that the advocates of various kinds of pumps and of the thermo-siphon system remain practically in the same proportion. The pumps are almost always gear-driven, only 7 per cent of the machines having friction-driven pumps, and 7 per cent of them having pumps driven by springs. The honeycomb radiator is more in evidence this year, 59 per cent of the cars being so equipped, in place of 53 per cent last year. The flanged-tube radiators have diminished from 47 per cent to 41 per cent. Radiators are generally fitted with fans, there being only 7 per cent which are not so fitted. The fans are placed as shown in the following table:

	1904. Per cent.	1905. Per cent.
Fan behind the radiator	70	69
Fan in flywheel	20	19
Both combined	10	12

Thus it will be seen that the same method of cooling is used as was employed last year, with a slight tendency in favor of the honeycomb radiator in place of the flanged tube type.

EFFICIENCIES.

By James Swinburne.

The term "efficiency" is used by serious people to denote the ratio of the useful part of the energy or power obtained, to the energy or power put in. There is another aspect of the question, and the term "efficiency" may be stretched to cover questions of money. For instance, if in a bargain you get 15s. worth of goods for £1 the purchase may be said to have an efficiency of 75 per cent. But in cases of this sort it is not quite usual for a bargain to have an efficiency of more than 100 per cent from each point of view. This is because in the case of a well conducted bargain, each of the parties, to use a legal word, gives what he prefers to part with for what he wants more; so that both are satisfied. But the seller may take another view; he may have bought an article for 15s. and sold it for £1. In that case he apparently makes 5s., and it might be called 33 per cent of the cost price, or 25 per cent on the selling price. The term "efficiency" is not applied to such cases, because "efficiency" is employed in cases where there is a partial loss, to show how much has not been lost. Cases of profit would be cases of efficiencies of over 100 per cent. A trader who looked upon buying at 15s. and selling at £1 as making a profit of 33 per cent would really be deceiving himself, because in such cases it is not really a question of how much is made over and above the apparent purchase price, but of what profit is made per annum on his trade capital. Into this question all sorts of considerations enter, that do not appear in the statement of simply buying and selling. If he is merely a trader who buys and sells he has to pay rent, incurs bad debts, loses stock through depreciation and other causes, and has to give his time to the work. He also may have to spend a good deal on advertising.

Another simple case is that of manufacturing. If an engine builder, for example, spends £1,000 on wages paid to men who have made an engine, and £1,000 for material, and sells an engine for £3,000, it is commonly said that he has no business with the odd £1,000; either he is said to have overcharged his customer £1,000, or he has robbed the workmen of £1,000, as it was their work that made the engine. Both these notions arise from ignorance; and this ignorance, like all other kinds of ignorance, does a great deal of harm. The argument that all the money paid to manufacturers should go to workmen who actually make the goods is always employed by the agitators who live by stirring up the passions, and flattering the weaknesses of their victims. It may seem strange to bring forward such questions in an address to electrical engineers; but I want to urge the importance of looking at things from a money point of view, because all engineering is a question of money; and I want to bring some money questions as well as energy and power questions before you to-night.

In making any bargains with Nature, we always lose in a sense; and we are so accustomed to it that we take it quite contentedly, and merely try to lose as little as possible in the transaction. As I said before, the relation of what we do not lose to the whole is termed the "efficiency." In dealing with our fellow men we always hope to make a profit, and we sometimes do. In such a case it might be correct to talk of an efficiency of over 100 per cent, but it would be unusual. It might be still more unusual to say a bankruptcy which resulted in a payment of 6s. 8d. in the £ was a transaction with an efficiency of 33 1-3 per cent. But there would be enough justification for such a proceeding to enable me to discuss some aspects, even of electrical commerce, under the head of "efficiency."

A BARGE FITTED WITH A SUCTION GAS-PRODUCER PLANT.

One of the largest examples of the application of suction gas engines to the propulsion of boats for river navigation is furnished by the river boat "Lotte," a barge with a flat wooden bottom 139½ feet long and 15 feet beam, carrying 240 tons upon a draft of 6½ feet. This was originally intended for service on the Elbe, but has been retained by the builders of the engines, the Otto Gas Engine Company, of Deutz, for their own carrying trade between Cologne, Antwerp, and Rotterdam. In order to obtain good balance for the engines, a four-cylinder horizontal arrangement has been adopted. The engine develops a total of 80 to 100 horse-power, which is sufficient to drive the boat about 3½ miles an hour against the current in the river. A sectional elevation of the engine as shown in Fig. 1 needs no explanation. The valve mechanism is clearly shown in another illustration, Fig. 2. The screw shaft is connected with the engines by a friction clutch. The gas producer is placed in front of the engine-room, from which it is separated by a bulkhead with sliding doors, which can be closed during the operation of cleaning the grate from ash and clinker. The screw is 4 feet 3 inches diameter, and is fitted with four blades reversible in direction by a rack and pinion motion; the reversing rod ends in a series of toothed racks which gear into corresponding pinions on the axes of the reversible propeller blades. The power required for reversing is taken from the main engine shaft by a combination including a friction clutch, bevel gears, jaw clutches, and helical gears, which screw the rod backward and forward, according as the jaw clutch shown in the lower right-hand corner of Fig. 3 locks one or the other of the two bevel gears to the shaft. This is brought into action by throwing the clutch into the back or forward gear as required when starting it by frictional coupling with the main engine. The motion necessary for any required pitch is marked on a divided scale, and this is varied according to the action of the engine, the pitch being gradually increased until the full load is attained.

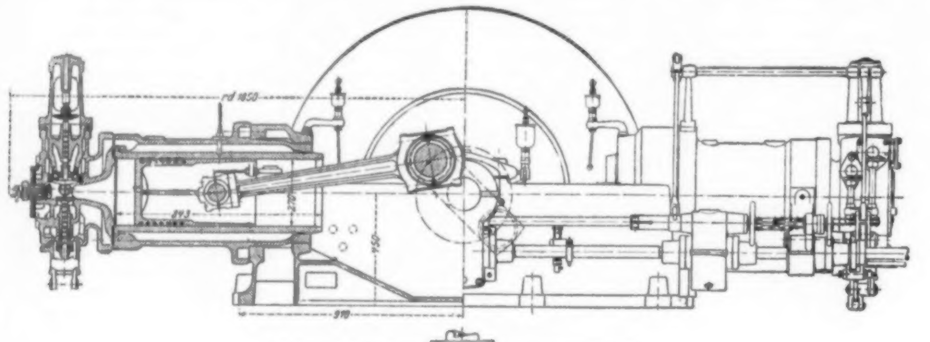


Fig. 1.—MARINE PRODUCER-GAS ENGINE.

For starting as well as for working the fan blower on the cargo winch on deck, a small benzine engine of 6 horse-power is provided, which starts the main engine by a frictional connection with the flywheel and keeps it running until ignition in the cylinder has commenced. When the engines have been standing for a long time the fan blower is used for a few minutes to enliven the combustion in the producer. This, as well as the deck winch, is driven by a belt and a line of overhead shafting.

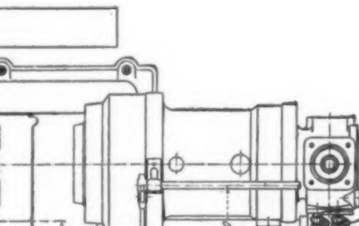


Fig. 2.—END VIEW OF ENGINE.

Up to the present time eleven different boats with suction gas plants have been built by the Deutz Company, the horizontal arrangement being used for the larger sizes, with two cylinders up to 45 and four for 65 to 90 horse-power, the latter running at 275 to 325 revolutions per minute. For smaller boats the ordinary vertical marine type of engine is used, with two, three, or four cylinders, mineral oil or alcohol being used as fuel. Boats of smaller power are largely used in Holland, and it is said that 280 of these, together developing 2,500 horse-power, have been supplied to that country by this firm, out of a total of 320, with 4,000 horse-power of engines.

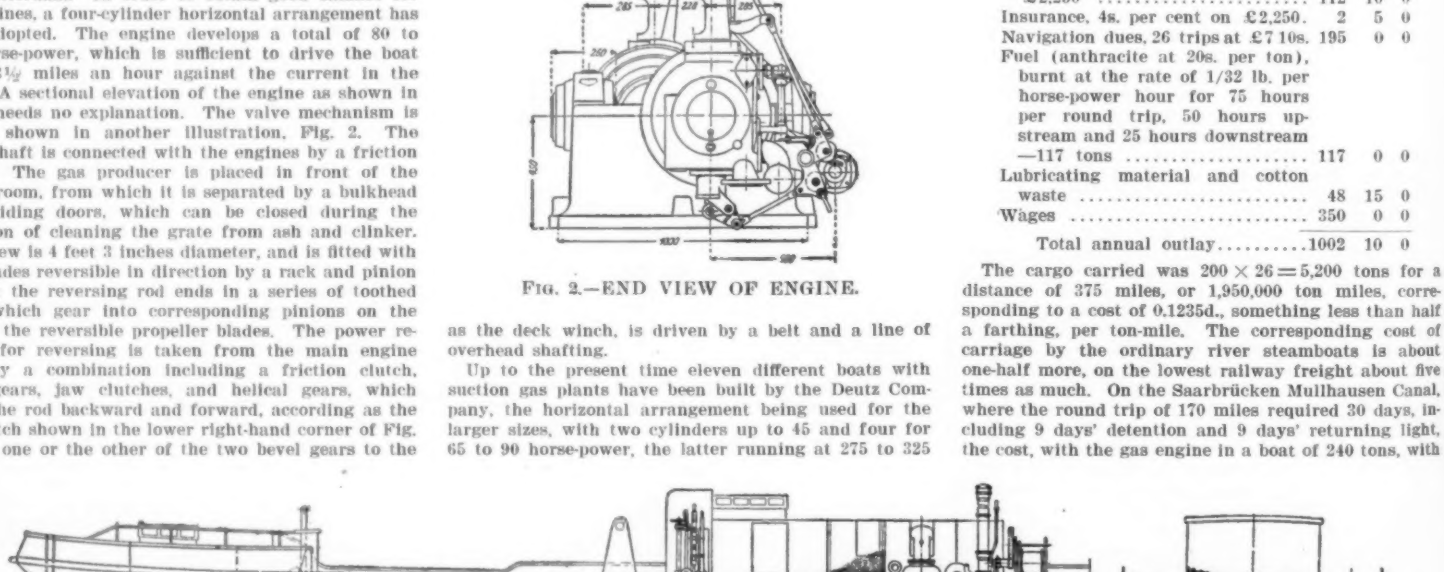
Cargo boats of the kind described above have been found to be extremely economical in working, the following results having been attained in the Rhine navigation between Cologne and Rotterdam—a distance of about 190 miles. With a boat of 250 tons carrying capacity, with an average load of 200 tons and engines of 100 horse-power, costing about $12,250, the average time required for the round trip, inclusive of all stoppages, is fourteen days, thus giving twenty-six voyages in the year.

Fig. 3.—STARTING AND REVERSING GEAR.

	£	s.	d.
Depreciation on hull, 5 per cent on £1,000	50	0	0
Depreciation on engines, 10 per cent on £1,250	125	0	0
Interest on capital, 5 per cent on £2,250	112	10	0
Insurance, 4s. per cent on £2,250.	2	5	0
Navigation dues, 26 trips at £7 10s.	195	0	0
Fuel (anthracite at 20s. per ton), burnt at the rate of 1/32 lb. per horse-power hour for 75 hours per round trip, 50 hours upstream and 25 hours downstream —117 tons	117	0	0
Lubricating material and cotton waste	48	15	0
Wages	350	0	0
Total annual outlay	1002	10	0

The cargo carried was $200 \times 26 = 5{,}200$ tons for a distance of 375 miles, or 1,950,000 ton miles, corresponding to a cost of 0.1235d., something less than half a farthing, per ton-mile. The corresponding cost of carriage by the ordinary river steamboats is about one-half more, on the lowest railway freight about five times as much. On the Saarbrücken Mullhausen Canal, where the round trip of 170 miles required 30 days, including 9 days' detention and 9 days' returning light, the cost, with the gas engine in a boat of 240 tons, with a 16-horse-power engine, was only two-thirds of that of horse traction, the boat making eleven journeys in the year by the former as compared with seven by the latter method.

Above we give an illustration of the general arrange-



RIVER BOAT WITH PRODUCER-GAS ENGINES.

ment of the machinery of the barge we have just described. The plant is very compact, and takes up little space. Attention should be directed to the small amount of room required for fuel storage. The arrangement of the propeller shaft can also be seen clearly in the illustration. We are indebted for the above particulars to the Zeitschrift des Vereines Deutscher Ingenieure.

[Continued from SUPPLEMENT No. 1569, page 25137.]

ARMORED CONCRETE.—IV.*

THEORY OF ARMORED CONCRETE BEAMS.

By LIEUT. HENRY J. JONES, A.O.D., A.R.C.Sc. (Lond.), Inspector of Ordnance Machinery.

FRANCOIS HENNEBIQUE is usually considered to have been the first to construct beams in armored concrete, but although he had designed floors and slabs so long back as 1879, he did not secure patent rights until 1892, and at that time general systems of construction had been introduced by Coignet and Cottançin in France, Möller in Germany, and Ransome in America. The Hennebique system possesses the merit of marked simplicity and the distinction of world-wide adoption; under his patent rights licensed contractors have erected over 10,000 structures at a capital outlay of over twenty million pounds, and the designs have stood the test of time. Unfortunately, however, from an academic point of view, the method of Hennebique's calculations is most irrational, and certainly has no relation to known facts; yet, curiously enough, the dimensions of beams calculated on his system do not differ materially from those of beams calculated on more elaborate, and seemingly, more rational lines. Thus a beam calculated on a system proposed by Prof. Hatt, to carry a uniformly distributed load of 6 hundredweight per foot run over a span of 16 feet, and having 1 per cent of armoring in cross-section, was 17 inches deep and 12 inches broad. The system of Koenen, which is used to calculate the Monier beams,

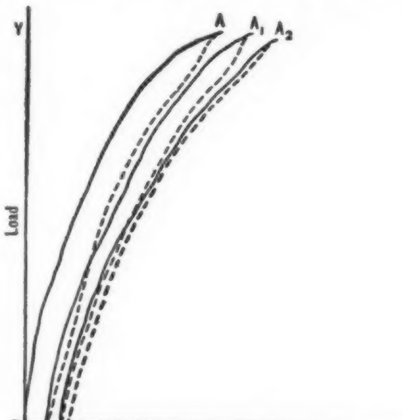


FIG. 1.—STRESS-STRAIN CURVES FOR CONCRETE.

gave the same proportions; and a Hennebique beam of the same dimensions to carry the same load required 0.96 per cent reinforcement. As the difficulties arising in any calculations concerning armored concrete are most obvious and best illustrated in the treatment of beams, we may consider these at some length.

The chief difficulty arises from the fact that armored concrete being heterogeneous—in fact, a mechanical mixture of substances whose properties are quite distinct—the ordinary properties of homogeneous substances are departed from in a most marked manner. The coefficient of elasticity of steel or iron is practically constant throughout the range of permissible strain, but that of concrete varies considerably with the load and the age of the concrete. Further, concrete is unique in the respect that it takes an appreciable permanent set under small loads; this, however, is usually confined to the first two or three loadings. The explanation of this initial set is probably to be found in the fact that, distributed throughout the mass of green concrete, there are portions of the aggregate only separated from other adjacent portions by a thin film of water and cement. When the cement sets, the film contracts; and it is easy to conceive, and microscopic examination actually shows, that discontinuities of material exist between various portions of aggregate. The first work of the initial load is to adjust the aggregate so as to eliminate these voids—to, as it were, bed the aggregate firmly in the cement. A consideration of the stress-strain diagrams for concrete may make the existence of this permanent set more clear.

If a column of concrete (say, about three months old) be loaded by steadily increasing increments, and a stress-strain curve be plotted from its indications, the result is of the following general character: Fig. 1 is a curve drawn from records with a circular column six inches diameter, two feet in length. On the first application of the load the stress-compression curve was OA, but on slowly removing the load the curve connecting stress with existing compression was AO_1. Thus OO_1 gives the permanent set. On again loading the column the corresponding curves were O_1A_1 and A_1O_2, showing the permanent set to be still appreciable, although not so large as that given by the first load. Repeating, the curves were O_2A_2 and A_2O_3, and beyond this no appreciable increase in the permanent set took place on subsequent loading. We thus get a total permanent set OO_3.

Besides illustrating the existence of this permanent set, the diagram also shows that Hooke's Law—the proportionality of stress to strain—is not even approximately followed. Since the coefficient of elasticity of concrete varies with the stress, it follows that it is impossible to express as a number the ratio of the coefficients for steel and concrete, if the ratio is to apply over all ranges of stress; for, while the former is practically constant, the latter is capable of wide variations. It has been stated that a variation in this ratio, to the extent of 50 per cent either way, introduces little difference between the calculated and observed strains; but it seems to have been forgotten that this unexpected result may solely arise from the "poisonous mathematics" used to determine what strain was to be expected. Christophe found that a column under simple compression, and with 1 per cent armoring, gave results differing only by 3½ per cent from those calculated; and even when the armoring was increased to 5 per cent, the difference was only 13 per cent. It has also been stated that with this 50 per cent limit of variation in the ratio of the coefficients, the moment of resistance of a slab with 1 per cent armoring only varied 16 per cent when the ratio was 50 per cent above the average, and only 12 per cent when the ratio was 50 per cent below. The ratio usually accepted as being a trustworthy average is ten, so that the coefficient of elasticity of steel is taken to be ten times that of concrete. If for any special purpose, or for any special nature of concrete the actual ratio is required, it can be readily determined.

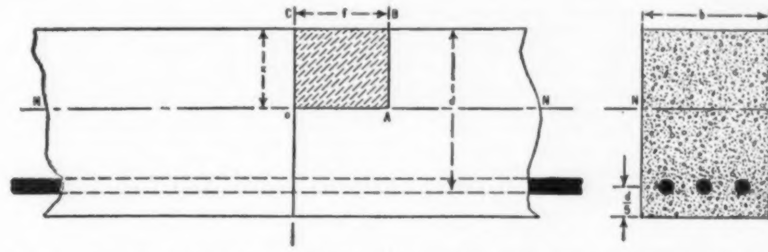


FIG. 3.—TO ILLUSTRATE HENNEBIQUE'S METHOD OF CALCULATING THE ARMORING REQUIRED FOR A CONCRETE BEAM.

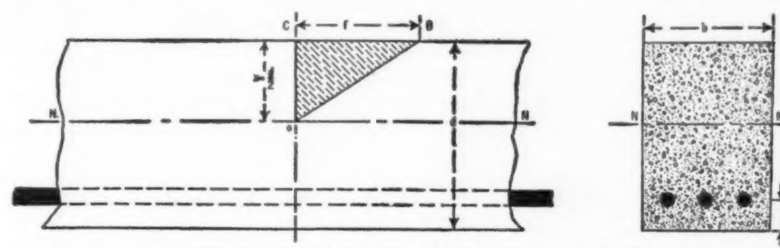


FIG. 4.—TO ILLUSTRATE KOENEN'S METHOD OF CALCULATING THE ARMORING REQUIRED FOR A CONCRETE BEAM.

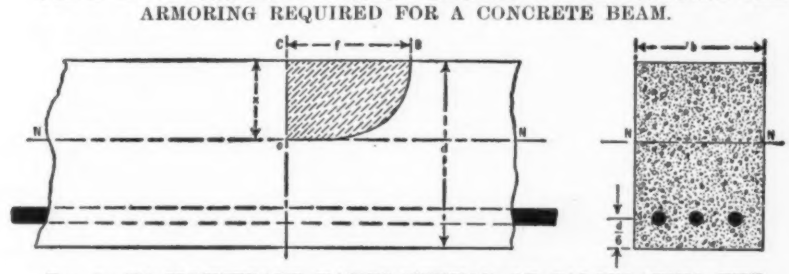


FIG. 5.—TO ILLUSTRATE HATT'S METHOD OF CALCULATING THE ARMORING REQUIRED FOR A CONCRETE BEAM.

The stress-elongation curves for concrete possess the same general characteristics as the stress-compression curves, and seem to indicate that, for small strains, after the initial permanent set has been produced the coefficients of elasticity in tension and compression are approximately equal. For small strains up to 20 per cent of the maximum strain in tension, the neutral axis of a simple concrete beam would thus be approximately at the middle of its depth, but for larger loads approaching the working limit the elasticities of the concrete differ greatly, and the position of the neutral axis becomes, mathematically, totally indeterminate, particularly when the state of stress is complicated by the existence of armoring. The value of the coefficient of the concrete in tension does not affect us greatly, as it is the invariable custom to neglect the tensile resistance of the concrete, and to treat the material on the tension side of the neutral axis as simply furnishing a mechanical bond to keep the armoring at the most advantageous distance from the neutral axis. It will be noticed, however, that the concrete in tension contributes to the definition of the position of the neutral axis; and as the elastic properties of the concrete vary with the stress, the position of the neutral axis at the center of a beam will be quite different from what it will be at the supports. For at the supports the tensile and compressive stresses are low, and the coefficients of elasticity are approximately equal; near the center of the span, however, the stresses will be high, and the coefficients unequal. Even at the same section of a beam the position of the neutral axis will vary as the loading proceeds. It would thus appear to indicate a want of perception of the limits within which mathematical analysis can be usefully employed, when investigators elaborate methods for defining the uncertain position of this roving neutral axis, and then neglect the tensile resistance of the concrete in determining the strength of the beam. Even for a simple concrete beam the stress-strain curve is very complex, and the only rational method of determining the deflection of an armored concrete beam seems to be that of Considere, who plots the stress-strain curves for the particular kind of concrete to be used, and then deduces the deflection curve. But the method

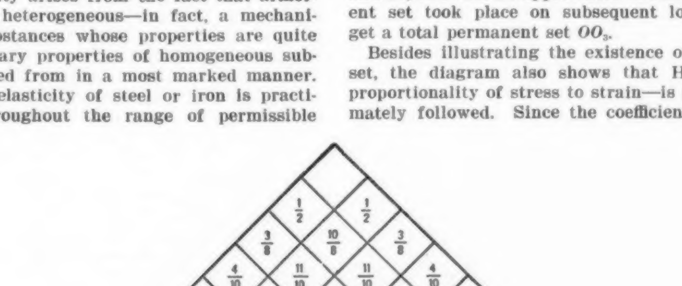


FIG. 2.—TO SHOW THE REACTION FOR A BEAM FREELY SUPPORTED AT SEVERAL EQUIDISTANT POINTS.

* Technics.

does not make for simplicity, is of little practical use, and is crude in so far that it neglects the disturbing influence of the armoring and the strains set up by the consolidating concrete. As before stated, it is most certain that initial stresses of considerable magnitude are induced in the armoring and the concrete as the setting of the latter proceeds; and this, combined with the initial permanent set, makes all mathematics which neglect these initial stresses merely folly mistaking itself for wisdom, and taking on the airs of exactness. Hennebique's irrational method is, in the circumstances, as good as any of the others.

Hennebique makes no preliminary investigation to determine the position of the neutral axis, but assumes this to be at a certain distance from the extreme edge of the compressed portion of the beam. He also assumes uniformity of stress in the compression side of the neutral axis, and equates the moment of the tension forces of the armoring to that of the compression forces of the concrete, about the neutral axis. Every assumption here is irrational. The position of the neutral axis cannot be stated for all beams and all loads, for its position will vary with the load even for the same beam. Further, uniformity of compressive stress is in direct contradiction to all experience and to the outcome of the elastic theory. The stress must decrease as we approach the neutral axis, because the strain decreases; and here, where the particles under compression are adjacent to those in tension, an abrupt change in the kind of stress is unthinkable. Again, under no possible conditions would the moment of the compressive stresses, however they might vary, be equal to the moment of the tensile stress in the armoring; for this would assume no tensile stress at all in the concrete, a perfect balance between the concrete and its armoring for all loads, and an invariable position of the neutral axis. Nevertheless, Hennebique's beams agree remarkably with others designed on contrary hypotheses, and maybe this may be due to the factor of safety (truly here a factor of ignorance) making one system as good as another, and the simplest the most desirable. It needs to be remembered, however, that if all theory is wrong which is inconsistent with practice, so also is all practice undisciplined, and as such misleading, which is incapable of explanation. We must therefore view Hennebique's methods with suspicion under extreme conditions.

Together with the particular assumptions peculiar to each of the many systems of calculation proposed, there are certain general assumptions adopted by all, a consideration of which will support the idea that any mathematical refinement in connection with armored concrete is, in the present state of our knowledge, inadmissible. These general assumptions are as follows:

1. That no initial stresses in the concrete or the steel arise from the setting or the permanent deformation of the concrete in the early stages of loading. We have already seen to what extent this assumption corresponds with actual facts; and we know the great strength of the Considere columns is a denial of its approximate accuracy; for the hoops and spirals are used simply because they will be put in compression by the contracting concrete, and be thus better able to stand the tensile stresses induced by loading.

2. That at all times there is continuity of material between the concrete and the imbedded steel, so that no slip of one over the other takes place, and any deformation, extension, or compression of the armoring is also exactly that of the immediately adjacent concrete. In view of the fact that the generally-admitted adhesion between steel and well-rammed concrete is from 550 pounds to 650 pounds per square inch, and that piles can safely bear repeated blows without visible disintegration of the materials, it would appear that no great error can be involved in this assumption. In many systems of construction, however, artificial means of preventing slip are resorted to. Cottançin, for instance, places no reliance on this adhesion, and is of the opinion that disintegration must take place under continuous vibration, unless mechanical means are taken to prevent it. He thus endeavors to place his armoring in such a way that the whole of the concrete is in compression when the armoring is in tension, and by placing his armoring in a sort of network he partially succeeds. Expanded metal meshing acts in the same way as Cottançin's network. When the meshing is in tension the meshes tend to close, and the concrete between the meshes is put in compression.

3. That the material of the beam behaves precisely as if each part were independent of the other—that, in fact, if the armoring is under a tension of five tons to the square inch, its strain and elasticity are unaffected by the adhesion of the concrete. This is obviously an incorrect statement, but one which we make for the simple reason that we can suggest none better.

4. That plane cross-sections of the beam before loading remain invariably plane throughout the whole range of the loading. This is the assumption made in the ordinary theory of homogeneous beams, but even in this case it is known to be only an approximation, very accurate when the span is large and the deflection small, but palpably incorrect for short beams, as an examination of a test-piece for bending will readily show. In the latter case the comparative magnitude of the longitudinal stresses causes the surface, initially plane, to become curved. In the case of armored concrete beams, the curvature of cross-sectional planes becomes much more marked. As we have seen, the coefficient of elasticity of concrete varies with the stress, and this alone would give rise to a deformation of the plane section under the action of bending stresses. This will be accentuated by the shearing stresses, which will be induced when armoring is present. Owing to the widely different elasticities of the steel and concrete, shearing stresses will be induced along the surface of the metal when the load is being carried, and these shearing stresses will correspond with shear strains in the concrete immediately adjacent to the metallic surface, even if no actual slip takes place. The result will be that the originally plane cross-section of the beam becomes warped, with a funnel-shaped depression in it round the metal. As a consequence, we must look upon this assumption of the permanence of plane sections as only a very rough approximation.

5. That the proportions of the beam are arranged so that, although the tensile stresses in the concrete are neglected, yet the maximum tensile stress induced by the load is never beyond the safe allowable stress for the concrete. Hence cracking of the concrete in tension is assumed to be avoided.

We can now proceed to a discussion of some of the more common methods of calculation. The maximum bending moment in a beam actually existing in ordinary structures is usually taken to be a mean between that for a similar beam freely supported, and that when rigidly fixed at the points of support. The table (Fig. 2) shows the reactions for a beam freely supported at several equidistant points, and is useful in determining the bending moment at any place. The load is assumed to be uniformly distributed.

Hennebique Method.—Let NN (Fig. 3) be the neutral axis of a beam shown in elevation and cross-section.

Let $AB = x$ be the distance of the neutral axis from the top of the beam.

Let d be the distance of the armoring from the top of the beam.

Let b = width of beam.

Let t = safe tensile stress in the armoring, which is assumed to be uniformly stressed.

Let f = safe compressive stress in the concrete, which is assumed to be uniformly stressed.

Let a = percentage of armoring exposed in cross-section of the beam.

Then, remembering that a covering of concrete of thickness $d/5$ is below the armoring, we have—

Moment of compressive stresses about the neutral axis

$$= f \,.\, x \,.\, b \,.\, \frac{x}{2}$$

The moment of the tensile stresses, neglecting those in the concrete,

$$= t \,.\, \frac{a}{100} \,.\, b\left(d + \frac{d}{5}\right)\left(d - x\right)$$

Assuming these to be equal, we may equate each to $\frac{M}{2}$, where M is the maximum bending moment.

$$\text{Hence, } fb\frac{x^2}{2} = \frac{M}{2}, \text{ or } x = \sqrt{\frac{M}{fb}} \ldots\ldots\ldots\ldots\ldots(1)$$

$$\text{Also, } t\frac{a}{500}bd\,(d - x) = \frac{M}{2};$$

$$\therefore \quad a = \frac{250}{6}\,\frac{M}{tbd\,(d - x)} \ldots\ldots\ldots\ldots\ldots(2)$$

$$\text{or} \quad a = \frac{250}{6}\,\frac{M}{tbd\left(d - \sqrt{\frac{M}{fb}}\right)}$$

b, the breadth, will be determined by the nature of the loads to be carried, and d is assumed to be from $3x/2$ to $5x/2$. For specified values of the other constants, a can be calculated when M is known.

If $d = 2x$, which is the usual assumption, and the values of t and f be taken to be 12,800 and 350 pounds per square inch respectively, a is very approximately unity, or the percentage of armoring is 1 per cent.

Koenen Method.—Koenen introduced this method about the year 1886, before any experimental research on the properties of armored concrete had been made. It possesses, in common with the method of Hennebique, the merit of simplicity and the demerit of irrationality. Suppose Fig. 4 represents a beam in elevation and cross-section. The neutral axis NN is assumed to be at the center of depth of the beam, and the stress at any place is taken to be proportional to its distance from the neutral axis, so that OBC is now the stress diagram for the concrete in compression. The armoring is assumed to be $\frac{d}{6}$ from the tensile edge of the beam. Using the same symbols as before, we have—

Moment of compressive stresses about the neutral axis

$$= f \,.\, \frac{x}{2}\, b \,.\, \frac{x}{3}$$

Moment of tensile stresses

$$= \frac{a}{100}\,tbd\left(\frac{5d}{6} - x\right)$$

Making $x = \frac{d}{2}$, and equating these moments to $\frac{M}{2}$ as before, we have

$$f\frac{bd^2}{24} = \frac{M}{2}, \text{ or } M = \frac{1}{12}fbd^2$$

$$\text{Also} \quad \frac{a}{300}tbd^2 = \frac{M}{2}, \text{ or } a = \frac{150\,M}{tbd^2}$$

The value of b will be determined by the nature of the loads: Koenen takes the values of t and f to be 10,650 and 430 pounds per square inch respectively, which makes a to be approximately 1 per cent.

Hatt Method.—Hatt assumes the stress curve for the concrete in compression to be parabolic (Fig. 5), and neglects the tensile strength of the concrete. Using the same symbols as before, and taking

E_c = modulus of elasticity of concrete in compression,

E_s = modulus of elasticity of steel,

we derive the following equations:

$$\frac{2}{3}fx = \frac{a}{100}bdt \ldots\ldots\ldots\ldots\ldots(1)$$

$$M = bd^2\left\{\frac{5}{12}fx^2 + \frac{a}{100}bdt\left(\frac{5}{6}d - x\right)\right\} \ldots\ldots\ldots\ldots\ldots(2)$$

$$\frac{a}{100}bd\frac{E_s}{E_c}\left(\frac{5}{6}d - x\right) = \frac{2}{3}x^2 \ldots\ldots\ldots\ldots\ldots(3)$$

These equations are obtained by equating the total compressive stress to the total tensile stress, and by taking moments about the neutral axis.

The ratio $\frac{E_s}{E_c}$ is taken to be 10, and t and f 12,800 and 430 pounds per square inch respectively. This makes a to be about 1 per cent.

These three methods of beam calculation are typical of the many others which have been proposed; and although the Hatt method is most in accordance with known facts, yet curiously enough the proportions of the beams and the percentage of steel in any of them do not practically differ. It would appear that the practice has been to design beams and determine experimentally what load they can carry; then to propose some so-called theory, and by adjusting the safe stresses of the steel and the concrete to make theory agree with practice—a method of procedure not altogether unknown in other branches of engineering.

(To be continued.)

THE PROBLEM OF THE GAS TURBINE.*

THE wonderful success obtained by the distinguished engineer, the Hon. C. A. Parsons, and his many able followers, with the steam turbine in its various forms, has naturally attracted the attention of engineers to the apparently analogous problem of the internal combustion turbine. Accordingly, much mathematical and engineering ability has been recently devoted to the subject—so far, I am sorry to say, without concrete result. In this subject, as yet, the dreams of the theorist obstinately decline to realize themselves in tangible iron and steel. I have not been able to find any gas turbine in a state of effective rotation doing useful work, although I have noted many statements in the press to the effect that some wonderful German, French, or Italian gas turbine had worked, or was about to work, in such manner as to relegate the ordinary cylinder and piston gas engine to the museum, with which many engineers used to threaten the steam engine. One gas turbine only has really rotated within my own direct knowledge. It was designed by Mr. F. W. Lanchester, of Birmingham, to operate with the exhaust gases from one of the petrol engines used in his well-known motor cars. He assured me a few days ago that it really rotated at a high speed, and made a loud shrieking noise, but only gave, he said, a total brake-horse-power equal to that capable of being evolved by two bluebottle flies. This power he did not consider to be satisfactory.

Speaking seriously, it does seem remarkable that so much interest should be taken by so many able men, without any sort of result in practice. Why is this? I propose to-night to answer the question in so far as I can. It appears to me that most of those who have written on gas turbines, and have even designed and patented them, have given too little weight to certain differences between the steam and internal combustion engine problems. Many, indeed, have assumed that the solution of the gas turbine problem is the easier of the two, and that few difficulties exist which have not already been met and conquered by Mr. Parsons in the steam turbine. Many distinguished men have been of this opinion, and even Mr. Parsons himself, so early as his first turbine patent (No. 6,735 of 1884), appears to have been of opinion that the hot gas or internal combustion turbine presented practically the same problem as the steam turbine. In that specification he makes the following statement: "Motors according to my invention are applicable to a variety of purposes, and if such an apparatus be driven it becomes a pump, and can be used for actuating a fluid column, or producing pressure in a fluid. Such a fluid pressure producer can be combined with a multiple motor according to my invention, so that the necessary motive power to drive the motor for any required purpose may be obtained from fuel or combustible gases of any kind. For this purpose I employ the pressure producer to force air or combustible gases into a close furnace of any suitable kind, such as used for caloric engines, into which furnace there may or may not be introduced other fuel (liquid or solid). From the furnace the products of combustion can be led, in a heated state, to the multiple motor, which they will actuate. Conveniently the pressure producer and multiple motor can be mounted on the same shaft, the former to be driven by the latter; but I do not confine myself to this arrangement of parts." Clearly here Mr. Parsons intended to apply his invention to the gas turbine as well as to the steam turbine, and in this paragraph he outlined the fundamental idea of nearly all subsequent proposals of gas turbines. Many other inventors

* Mr. Dugald Clerk's presidential address to the Junior Institution of Engineers.

have followed him, but I may only mention two well-known names—those of Ferranti and Stodola. Both have proposed turbines similar to this, with more or less elaboration, as well as other modifications intended to overcome certain difficulties.

In a very able paper read before the Institution of Mechanical Engineers last year, Mr. R. M. Neilson discusses various cycles of operation which can conceivably be applied to gas turbines, and he calculates the efficiencies of these cycles in various combinations. More recently, too, the subject has excited great interest in America, and very interesting articles are to be found in the Engineering Magazine by Dr. Charles E. Lucke and Prof. Sidney A. Reeve. These gentlemen take somewhat opposing views of the position of the problem.

In most of the recent discussions upon the gas-turbine problems, it has been recognized that the temperatures possible in the cylinder gas engine are impossible for the gas turbine. It has been fully proved by many investigators, including myself, that the temperatures quite common in ordinary gas-engine practice range as high as 2,000 deg. C., although in the best practice, for most economical results, 1,500 deg. C. or 1,600 deg. C. appears to be an upper limit. With the temperatures of 1,500 deg. C. or 1,600 deg. C., a first class modern gas engine of about 50 horse-power will give an indicated efficiency of 35 per cent. At the same time the negative work of the cycle is so low that the mechanical efficiency of the engine may be as high as 86 per cent, or even over. If one realizes what the temperature 2,000 deg. C. means, it becomes very evident that no turbine constructed either on the lines of Parsons or Laval could possibly be made to work with continuous supply of such gases; 2,000 deg. C. is considerably over the melting-point of platinum. It is much higher than the temperature at which cast-iron flows from the crucible, or, indeed, the temperature of the interior of the blast furnace itself. Any blades of iron, steel, or, in fact, of any other material, even brick-fire itself, become fluid or semi-fluid at this temperature. It is obviously hopeless, therefore, to attempt, in the gas turbine, temperatures which are quite feasible in the cylinder engine. This fact, as I have said, is generally recognized. It is accordingly said, by those who take a favorable view of the gas turbine, that it is necessary to supply the turbine with gases at a much lower temperature. Mr. Neilson fixes the temperature of 700 deg. C. as one which steel-turbine blades would probably stand, without too rapid deterioration. I fear that on this point I must differ from him, because, in my experience, oxidation of steel, and even iron, is a fairly rapid process at this temperature. Nothing new has been proposed as to the thermodynamic cycle of the gas turbine, so that all reasoning upon efficiencies depends upon the deductions already made from internal combustion engine practice.

Seeing the impossibility of constructing a turbine with materials to stand a high temperature, many have proposed to convert high temperature into kinetic energy, so that instead of having work stored up in the gas in the form of heat, the heat shall disappear, and the energy of the heat be transformed into motion of the gaseous particles at a high velocity. Such proposals, then, include the compressing of a gaseous mixture to, say, 50 pounds or 60 pounds above atmosphere, the igniting of that mixture within a combustion chamber at constant pressure, and the expansion of the mixture through an expanding jet of the Laval type, so as to drop the temperature and obtain its equivalent in kinetic energy or velocity of the gaseous particles. The rapidly-moving particles at the relatively low pressure and temperature are then allowed to impinge upon rapidly-rotating blades of sickle configuration, and they are supposed to give up their energy of motion to those blades, and so expend work upon the turbine. This appears to be the most feasible of all the gas turbine proposals, so I will proceed to examine it a little more minutely.

Success by this cycle of operations requires: (1) A rotary or turbine compressor of high relative efficiency. (2) An expanding nozzle which shall insure that free expansion is quantitatively equivalent to adiabatic expansion behind a piston. (3) A rotating turbine of such construction as to secure very high efficiency of transformation of kinetic energy of the moving gas into effective work available at the turbine shaft.

Assuming air to be the working fluid, and specific heat to be constant through the temperature range, it is easy to calculate the efficiency of the Joule or Brayton cycle, which these operations in effect represent. It would be useless to attempt to work a turbine at a pressure so low as to be relatively inefficient compared with the gas engine, so I have chosen a Joule cycle of, say, 48 per cent ideal efficiency, which in a cylinder gas engine would probably give in practice about 30 per cent indicated efficiency. For this ideal efficiency the pressure of compression would require to be 141 pounds per square inch absolute. To give power with a reasonably small pump, I shall assume a maximum temperature of 1,700 deg. C. That is, assuming a perfect compressor and a perfect nozzle expander, the temperature would only fall from 1,700 deg. C. to 750 deg. C. Plainly this temperature would be too high for a Laval disk with blades. In order to get a reasonable temperature on expansion, it would be necessary to assume a maximum temperature in the combustion chamber no higher than 1,000 deg., and this would bring down the temperature after complete expansion to about 500 deg., which no doubt steel turbine blades can be expected to stand for some considerable time. With these assumptions, however, the gas turbine would not be very economical as compared with cylinder engines, even assuming all difficulties overcome. The theoretical and practical difficulties, however, are very serious indeed. To begin with, the question of an efficient air compressor. I am not aware of any turbine compressor capable of compressing up to 140 pounds absolute from atmosphere with anything like 60 per cent efficiency. Before success could be attained this efficiency of compression, so far as diagram is concerned, should be at least 90 per cent, in order to allow for unavoidable mechanical and other losses in the subsequent processes. It has, it is true, been proposed to substitute cylinder compressors operated from the turbine instead of turbine compressors; but this, it appears to me, would be equivalent to abandoning at once all the advantages of the turbine principle. If reciprocating cylinders are to be used for compressing, there is no objection to using them also for expanding. No gas turbine with cylinder compressors could, in my view, succeed.

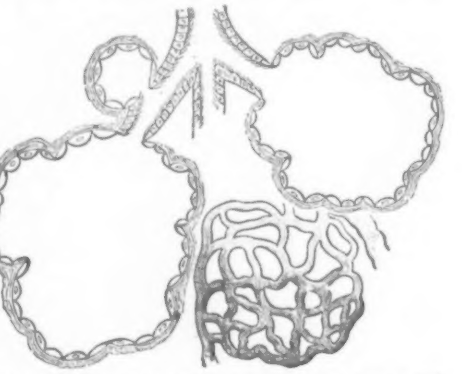
Assuming, however, even 90 per cent efficiency from a turbine compressor, and assuming that we have a compressed gaseous mixture burning freely in the combustion chamber at the desired pressure and temperature, we have yet to face the problem of the expanding nozzle. It is always assumed that with the use of an expanding nozzle temperature drop can be as certainly attained as with an expanding piston in a cylinder. This, it seems to me, has been by no means proved. You will all recollect Dr. Joule's famous experiment with two vessels immersed in water and connected together by a pipe having a stop cock upon it. Air was compressed into one of those vessels, the water round the vessels stirred, and equilibrium obtained, while the other vessel was rendered as vacuous as possible. The stop cock between the two vessels was opened, and it was then found that when the water was stirred again no disturbance of the equilibrium ensued. This, of course, meant that although heat was lost in the one vessel, giving velocity to the gases, it was gained in the other vessel by the impact of the gases against the walls. Joule modified this experiment by placing the two air vessels in separate water containers. He then found that the temperature of the one vessel dropped, due to expansion, but the temperature of the other vessel rose as much as the first dropped. Now apply this experiment to reasoning on the behavior of the flame in an expanding nozzle. Assume the two vessels to be connected together by a Laval nozzle, and assume that, while in the nozzle, the gases experienced the full temperature fall due to adiabatic expansion. Immediately, however, on contact with the walls of the second vessel the velocity of the particles would be stopped and the temperature would be restored to a point somewhat above the original temperature—that is, the mass of expanding flame in the pressure vessel would gain heat by the amount the first vessel lost. That is the result of the final process. It will be easily recognized that to obtain a sufficient temperature drop in an expanding nozzle necessitates the practical absence of turbulent motion of every kind—that is, to expand adiabatically the jet must be so constructed that there is an absolutely smooth flow from high pressure to low, and no impact or loss of velocity from any cause whatever. So far as I understand expanding jets, no adiabatic expansion so perfect as this has ever been obtained.

Assume, however, that the efficiency of expansion in such a jet is, say, 90 per cent. We now come to the question of the efficiency of conversion by the turbine blades. In many calculations from diagrams it is assumed that the efficiency of conversion of motion into work is practically perfect. This, however, is by no means the case in present turbines. Even the steam turbine, high as its efficiency is, compared with the reciprocating engine, has no very high efficiency of conversion in any of the forms of turbine at present on the market. That is, if we assume a mass of gas to exist in a compressed state in a reservoir, and we choose to expand this mass of gas in two ways, for the sake of comparison—(1) behind a piston, and (2) by means of a Laval jet and turbine—we shall find that the efficiency of conversion of the turbine, once high velocity is attained, does not exceed 80 per cent. In this respect the efficiency of conversion of rotating turbine blades is inferior to that of a moving piston in a cylinder. The reason of this is obvious. It is impossible to arrange the impact of a rapidly-moving gas with a turbine blade or blades in such manner as to entirely avoid turbulent motion. The impact, for example, of swiftly-moving gases on a fixed surface results ultimately entirely in turbulent motion, which restores to the gas or to the blade struck all the heat which has disappeared in temperature fall due to adiabatic expansion. What is true of a fixed blade is to some extent true of moving turbine blades. A certain proportion of the energy existing in the gas in the form of motion is inevitably lost whenever this gas comes into contact with any solid surfaces. So much is this the fact that in designing steam turbine blades for any type of turbine the shape of the blades, the shape of the space between the blades, both moving and fixed blades, or fixed jet and moving blades, is of the first importance, and it has only been found by experiment that certain shapes of blades and passages have a much higher efficiency of conversion than other shapes. In this respect, too, the turbine principle is inferior to the cylinder and piston. In a cylinder, gases expanding behind the piston, the efficiency of expansion may be considered to be 100 per cent, and even the efficiency of compression in many gas engines is also of the same order. I do not here refer, of course, to heat losses due to conduction or anything of that kind, but to efficiency of adiabatic compression or expansion.

Although the efficiency of expansion is relatively low for gases in steam turbines, yet the turbine offers a great advantage in total work obtained from steam. This is due to the fact that the turbine avoids initial condensation; and, further, it permits of the utilization of a very long range of expansion at the low-pressure end, which is not available in the case of steam engines. By saving, therefore, in minimizing initial condensation, and in obtaining added work from pressures wasted in the ordinary steam engine, the Parsons steam turbine more than compensates for any efficiency of expansion as compared with the cylinder engine. It is well known, however, in turbines of practically all constructions, including Mr. Parsons's, that the efficiency of the steam turbine at the high-pressure end is not so great as that at the low-pressure end. This is partly due to difficulty of adjusting the velocity of blades to suit the necessarily varying velocities at different points of the flow of the steam. This, however, is a small difficulty with the steam turbine, but it is a very great difficulty with the gas turbine. Compared with cylinder expansion, I cannot see how it is possible with present knowledge to obtain an efficiency of conversion in a gas turbine greater than 80 per cent. This, of course, is partly due to the high velocity of the issuing hot gases. To produce an efficient gas turbine, therefore, on the favorite cycle so much discussed recently, it is necessary first to have, as I have said, a very efficient compressor, a very efficient expanding nozzle, and a very efficient conversion when the moving gases strike the turbine blades. Using the numbers I have suggested, of 90 per cent efficiency of compression, 90 per cent efficiency of nozzle expansion, and 80 per cent efficiency of conversion in turbine, we have, with a cycle having negative work equal to 0.4, the following efficiencies: To get 0.4 of work in compression, we shall require 0.445 of work put into the compression. On expanding in the nozzle we shall obtain 0.9 only of the total energy of the flame gases in the shape of kinetic energy, and of that 0.9 we shall only get 0.8 returned in the shape of available work by the turbine part. That is, we shall get a total work from the turbine of 0.72, and deducting the negative work 0.72 — 0.445 = 0.275—that is, from a cycle which would give us 0.6 in work, we shall only get 0.275, or about 22 per cent. The practical efficiency of an engine of this kind will only be 22 per cent, even assuming the high efficiencies of compression and jet expansion which I have mentioned. In my view, no such efficiencies of compression or jet expansion are at present known, and accordingly there appears no likelihood of the production of any gas turbine which can rival the reciprocating gas engine in efficiency and in economy. To produce such a turbine requires the solution of three problems: (1) An efficient turbine compressor, comparable in efficiency with cylinder compression. (2) An efficient nozzle expander with a higher efficiency than 90 per cent. (3) An efficiency of conversion of kinetic energy of the moving gases into work delivered at the turbine spindle of greater than 80 per cent. Either these problems must be satisfactorily solved or else new materials discovered which will stand temperatures which at present melt fire-brick. The outlook, I fear, is not hopeful. This thermal efficiency of 22 per cent assumes no losses in the combustion chamber due to heat conduction, no losses in the expanding jet due to heat conduction, and no losses in the turbine itself from the same cause. Considering the losses in gas engine cylinders of small size, it would not be too much to allow in a turbine a heat flow loss of at least 25 per cent. This, of course, reduces the efficiency from 22 per cent to 16.5. In arriving at this figure, I have assumed that no greater loss would be incurred from heat flow in the turbine than in the cylinder engine; but even with reduced temperatures when striking the turbine, the very fact of requiring a reservoir for combustion to operate, and the forcing of the whole of the hot products through a relatively small nozzle, necessarily means greater loss than I have assumed. Assuming, however, no more loss than I have given, an engine with an efficiency of only 16½ per cent of the total heat given to it would not compete with internal combustion motors of existing construction. It may be said that the advantage of continuous rotation is so great that even at this low efficiency the gas turbine would be successful. Personally, I doubt it very much, because the mechanical difficulties with gas turbines would be much greater than the mechanical difficulties of the steam turbine. In all steam turbines, as you, I am sure, know, it is necessary to work with relatively small clearances between the tips of the blades or shrouding and the inclosing casing. This is also true as to endwise clearance between fixed and moving blades. Comparatively small clearances are necessary for economy. The use of even temperatures so high as 400 deg. C. or 500 deg. C., by introducing unequal expansions, greatly increases the difficulty of obtaining economy. No doubt if a plentiful supply of relatively low temperature gases under considerable pressures could be obtained, these gases might with advantage be expanded in a nozzle and used to operate a turbine. To carry this idea into effect has already been attempted, as I have said, by Mr. Lanchester, and there is some hope of operating in this way. I fear, however, that the temperature of the gases in the exhaust in the gas engine are too high as they stand to be so used. Gases, however, from an exhaust or air

supercompression engine, such as I have lately been working with, could no doubt give considerable efficiencies in turbines. I do not see, however, any solution of the gas turbine problem here, because the amount of energy available for the turbine after the gases leave the gas engine is too small for consideration in connection with any really high-power machines.

Some of the difficulties I have discussed with you have been mentioned by Dr. Lucke. He adopts the view that jet expansion is not as efficient as piston expansion, and here I agree with him. No doubt the

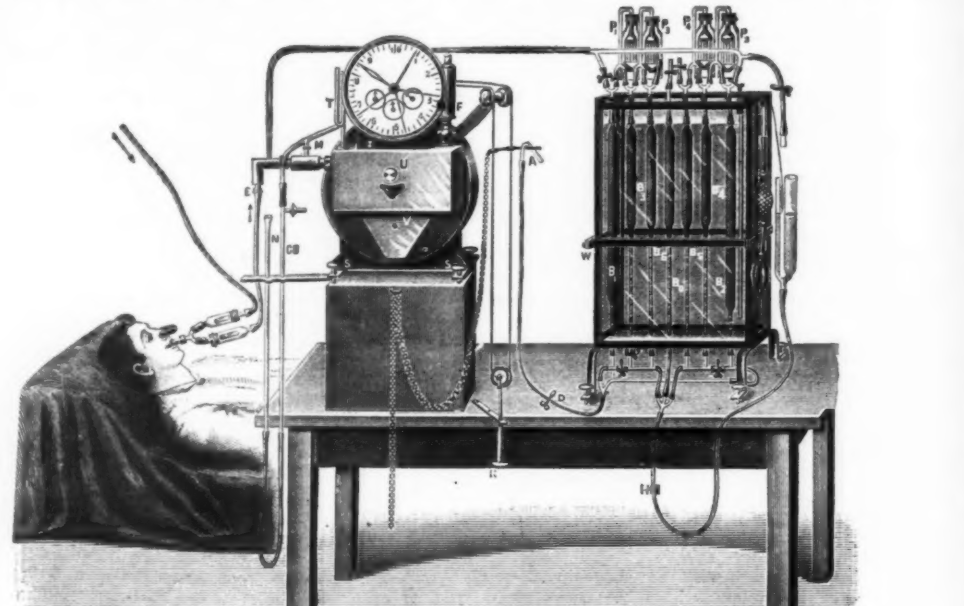


EXCHANGE OF GASES BETWEEN AIR AND BLOOD IN THE LUNGS.

type of jet expansion has to be carefully considered, and the efficiency of a jet as a means of converting the expansion from a high pressure to a low into kinetic energy depends entirely upon its configuration, and the design of the proper areas and relative lengths for the nozzle. All this, however, is as yet a relatively new field, and much study will be required before any certainty can be attained in the design of expanding jets. Prof. Reeve, in another able article which I have already mentioned, differs from Dr. Lucke, and considers that he has overstated the difficulties of the expanding jet. He accordingly takes a more favorable view of the turbine problem. There is a great deal of truth, however, in what Dr. Lucke has said. Even the best expanding jets yet known appear to have a low efficiency, and nothing is known of the efficiency of expansion starting from flame temperatures. Apart from the mechanical efficiency of the expansion, as I have already pointed out, the heat loss due to conductivity will be great in such nozzles. I quite agree with Prof. Reeve, however, that the more hopeful line for the gas turbine lies in the use of steam to provide the working fluid under compression without a compressor, and in the heating of this steam when produced by a very small quantity of combustible mixture of gas and air under pressure. Such a turbine would be a compromise between what I may call the flame turbine and the steam turbine, and it presents more possibilities; but its efficiency would not be high, although no doubt such a machine could be got to operate mechanically with fair success. This line of work depends upon the fact that negative work may be greatly reduced by using steam as working fluid, when steam is heated highly by internal combustion of a relatively small amount of inflammable gas and air. This proposal is more hopeful, but for success, even, it requires temperatures, in my view, too great for existing turbines to stand with economy. This proposal may be considered to be analogous to that of an excessive superheat, as used in an existing steam turbine.

Many methods have been discussed which depend upon the use of regenerators. I have a great distrust of regenerators, so far as engine work is concerned. Many able men have proposed regenerative contrivances, from the time of Stirling, in 1817, down to the present day; but I am not aware of any actual working engine which has ever succeeded in practice, using a regenerator.

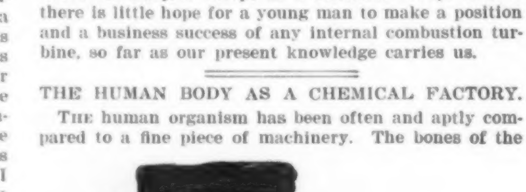
From what I have said, you will see that my view of the future of the gas turbine is not favorable; but, notwithstanding, the subject is so fascinating that many inventors and scientific men will doubtless continue to investigate the problem, and possibly new solutions may be discovered which are not dreamt of to-day. I am the last man in the world to deprecate daring in any practical and scientific work, but I would advise the junior engineers—members of our Institution—to avoid the subject except as a scientific study. I fear there is little hope for a young man to make a position and a business success of any internal combustion turbine, so far as our present knowledge carries us.



APPARATUS FOR MEASUREMENT AND CHEMICAL ANALYSIS OF INHALED AND EXHALED AIR.

THE HUMAN BODY AS A CHEMICAL FACTORY.

The human organism has been often and aptly compared to a fine piece of machinery. The bones of the



NINE OUNCES OF CARBON, THE QUANTITY EXHALED, AS CARBONIC ACID, BY A MAN IN 24 HOURS.

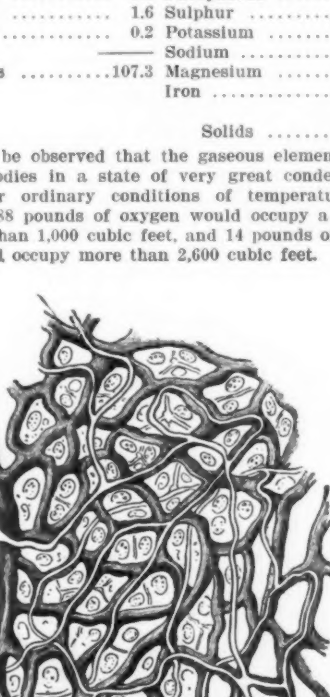
skeleton, held in position, moved and guided by a system of muscles and tendons, fit together like the wheels and levers of a watch. The mainspring of the machine is the heart and its regulator is the nervous system. No human hand ever constructed, no human mind ever invented so marvelous a mechanism, for all its wheels and levers are instinct with life. Millions upon millions of living cells make up the structure of the body. Each cell is a chemical laboratory and the whole community of cells constitutes a great chemical factory, where no holiday is ever kept, but vital force is incessantly created and converted, by wonderful physiological processes, into heat, work, and electricity, and life is continually destroyed and reproduced. The scientific name of this mysterious activity of our chemical factory is "metabolism."

THE QUANTITY OF OXYGEN CONSUMED BY A MAN IN 24 HOURS BY BREATHING FILLS A BOX 9 FEET LONG, 3 FEET HIGH, AND 3 FEET WIDE.

Let us look a little more closely into this complex metabolism of the human chemical factory. The millions of cells of which the body is built up vary in form and character, in function and composition. In the first place, we naturally ask of what materials they are composed. Of what does man consist? Chemistry gives a precise answer to this question. He consists of 13 elementary substances, of which 8 are solid and 5 are gaseous at ordinary temperatures. The solids are carbon, calcium, phosphorus, sulphur, potassium, sodium, magnesium, and iron; the gases are oxygen, hydrogen, nitrogen, chlorine, and fluorine. Each of these elements preserves its chemical identity under all conditions. As the eminent Berlin physiologist, Du Bois Reymond, has remarked, an atom of iron remains the same whether it is traversing space in a meteorite, revolving in a carwheel or coursing through a poet's brain in a blood corpuscle. Science also gives us definite information concerning the quantities of these 13 elements that occur in our bodies. A man weighing about 160 pounds is made up of:

	Lbs.		Lbs.
Oxygen	88.0	Carbon	44.00
Hydrogen	14.0	Calcium	3.5
Nitrogen	3.5	Phosphorus	1.6
Chlorine	1.6	Sulphur	0.2
Fluorine	0.2	Potassium	0.16
		Sodium	0.14
Gases	107.3	Magnesium	0.10
		Iron	0.09
		Solids	49.8

It will be observed that the gaseous elements exist in our bodies in a state of very great condensation, for under ordinary conditions of temperature and pressure 88 pounds of oxygen would occupy a volume of more than 1,000 cubic feet, and 14 pounds of hydrogen would occupy more than 2,600 cubic feet.



EXCHANGE OF GASES IN THE LIVER.

These elements, united to form an infinite variety of compounds which are continually undergoing chemical transformation, make up our bodies, which are ever decaying and being renewed. But nothing of all this is apparent to the eye, for one of the great enigmas of animal life is the permanence of form that persists through continual change of substance. This

change is so rapid that, according to the calculations of Liebig, Moleschott, and other eminent physiologists, the greater part of the material of the body is renewed every 20 or 30 days. The popular belief that the body is renewed only once in seven years is therefore erroneous.

The source of material for construction and reconstruction is the food. Nutritive substances must be supplied to repair the losses which the body suffers through metabolism. It has been observed that a normal, robust man of middle age loses about one-fourteenth of his weight in twenty-four hours in summer, and one-twelfth in winter. The loss increases with the man's strength and activity. The rapidity of metabolism, as Moleschott observes, is the measure of life. The greatest intensity of metabolism occurs between the thirtieth and fortieth years of life, that is to say, in the period in which man's creative energy is most fully developed. It is greater in men than in women and children, and it is greater in workers than in idlers.

Now, the daily loss of from 1/14 to 1/12 of the weight of the body amounts, for a man of 160 pounds weight, to from 11 to 13 pounds—a goodly quantity, which must be supplied as daily food if the bodily economy is not to suffer, and the body to lose its strength, capacity for work, and power of resistance.

Here a distinction must be made between food and nutriment, which are commonly regarded as synonymous. Food contains nutriment in smaller or greater amounts and that food is the best which contains the largest proportion of nutriment. From the food the nutriment is extracted in the chemical factory of the body, and from the nutriment the special chemical laboratories, the cells, form the bodily tissues and the final products of excretion, which in the general cycle of organic life are eventually used in the formation of new food and nutriment.

Now, though man—proverbially—cannot live on air, yet in order to live, he needs air more than all else, for it contains the most important of all nutriments, oxygen, without which life is impossible. For to live is to breathe, to burn, to oxidize, and the body, considered merely as a machine, is a heat engine. History supplies many terrible instances of deaths caused by lack of oxygen among persons crowded into caves and prisons. As soon as the proportion of oxygen in the air, which is normally 21 per cent, falls to 7 per cent, suffocation begins. In tranquil breathing a little more than a pint of air is inhaled and exhaled in each complete respiration. But though the quantity is the same, the quality of the expired is very different from that of the inspired air. While the latter contains about 21 per cent of oxygen, 79 per cent of nitrogen, 0.84 per cent of water vapor and 0.04 per cent of carbonic acid, the air expelled from the lungs contains much more carbonic acid and moisture and much less oxygen, the quantity of carbonic acid given off being increased by exertion and greater with vegetable than with animal diet. From numerous ingenious experiments, one of which is illustrated herewith, it has been learned that a man of medium weight absorbs, from the 7.5 liters [457.66 cubic inches] of air inhaled in a minute, 518 milligrammes [8 grains] of oxygen and excretes in the same time 619 milligrammes [9½ grains] of carbonic acid. In 24 hours, therefore, he absorbs about 750 grammes [26 ounces] or 520 liters [143 gallons] of oxygen, and excretes about 900 grammes [32 ounces] or 450 liters [124 gallons] of carbonic acid.

The oxygen and the other constituents of the inhaled air pass through the windpipe and all the branches and chambers of the lungs until they reach the thin-walled "lobules," which they fill and distend. These lobules are surrounded by a fine network formed of the small ramifications of the pulmonary blood vessels, and an exchange of gases takes place through the thin porous walls of both blood vessels and lobules, which are in close contact. Oxygen enters the blood vessels, combines chemically with the blood corpuscles and is carried with the blood through the arteries and their fine terminations, the capillaries, which permeate every part of the body. The capillary network, again, converges into the system of veins. In its passage through the capillaries, the blood gives up its oxygen to the chemical laboratories, the cells, receiving carbonic acid in exchange, which it conveys to the lungs to be again exchanged for oxygen, as has been described. A similar, but much smaller exchange of carbonic acid for oxygen, takes place through the skin.

But the chemical factory of the body requires also, for the manufacture of its great variety of products, material more substantial than air, and this is supplied, or rather concealed, in food. The oxygen is, so to speak, merely the fuel for the engines and retorts—a wonderful fuel, for it bathes, heats, permeates, unites with and transforms the retorts and their contents alike.

The most important nutriments are albuminoids, fats, carbohydrates, water, and mineral salts. The celebrated physiologists Voigt and Pettenkofer, of Munich, have computed the quantities of these substances required every 24 hours, as follows:

	Laborer.		Metal worker.		Prisoner.	
	Grms.	Oz.	Grms.	Oz.	Grms.	Oz.
Albumen	118	4⅛	127	4½	77	2¾
Fat	56	2	89	3⅛	22	¾
Carbohydrates	500	17½	362	12¾	305	10¾
Water	2500 to 3000	90 to 100	..	..	..	..

It must be remembered that a much larger quantity of *food* must be provided to supply this amount of *nutriment*. Eighteen eggs would be required to furnish the 118 grammes of albumen and 4 or 5 pounds of bread must be eaten to obtain 500 grammes of carbohydrates, if they are not provided in any other form.

What happens to food and nutriment when they enter the human chemical factory? As soon as they have passed what Homer calls "the fence of our teeth" they are subjected to various chemical processes, all of which tend to utilize them as thoroughly as possible for the benefit of the body. The process of digestion begins in the mouth, where some of the starch is converted into sugar. The stomach attacks the albuminoids, dissolves the salts, liquefies the fats and in the long intestinal canal the chemical and physiological transformation continues until the nutriment has become fit to be received into the blood. The chemical processes concerned in this preparation are exceedingly complex and they involve a number of spécial products, of which the most important are bile and pancreatic fluid. Every 24 hours the organism secretes 800 cubic centimeters, or nearly a pint, of bile and 150 grammes, or 5¼ ounces, of pancreatic fluid. The bile saponifies and dissolves the fats, the pancreatic fluid resolves them into glycerine and fatty acids and also, like the saliva, converts starch into sugar and, like the gastric juice, converts albuminoids into peptones.

The nutrient paste thus produced is absorbed by the villi of the mucous coat of the intestines. These villi are little thread-like extensions of the mucous membrane each of which contains a finely branched lymphatic vessel. (Lymph is blood which contains no red corpuscles.) The cells of the villus extend themselves like arms to seize the particles of the nutrient paste and carry them to the lymphatic duct. All of these countless ducts converge to a system of large lymphatics terminating in one main trunk which empties into the venous system. Thus the nutriment flows with the blood through the entire organism, reaching all the thousands of little laboratories of the factory in which it is used in the formation of tissue and finally being excreted as a waste product. In these little laboratories begins the wonderful process which chemists call retrogression. Here, with the aid of the consuming oxygen, the constituents of the blood are disintegrated, first into tissue-builders and then into the final products of decomposition. Nutriments may be divided into two great classes, nitrogenous and non-nitrogenous. The chief nitrogenous nutriments are the albuminoids. The non-nitrogenous class includes the fats and the carbohydrates, which may be designated as fat formers and are represented in food by starch and sugar. The last stage in the retrogression of nitrogenous substances in the cell-laboratories is represented by urea, the most highly oxidized product of combustion, the formation of which is preceded by a number of intermediate stages. The non-nitrogenous nutriments, the fats and fat-formers, are finally oxidized into carbonic acid and water, the successive intermediate products of combustion being lactic, butyric, acetic, formic, succinic, and oxalic acids.

The ultimate results of metabolism, therefore, the final products of the chemical factory of our organism, are water, carbonic acid, and urea. These may be called the sewage of the factory, and the kidneys, skin, and lungs are the sewers which remove these products of decomposition from the organism. Water is excreted by the kidneys as urine, by the skin as perspiration, and by the lungs as aqueous vapor. Altogether, about 6½ pints of water are excreted daily. Carbonic acid is given off by the lungs and skin to the amount of 32 ounces, or 124 gallons, daily. The quantity of urea which the organism produces in 24 hours is from 30 to 40 grammes, or from 1 to 1½ ounce.

But these chemical processes of oxidation and disintegration, which are continually going on in the body, have another result. The chemical actions produce heat, the bodily heat which makes the temperature of the body nearly independent of external conditions. Additional heat is produced by mechanical work and the work of the heart, and is therefore an indirect result of metabolism. It has been computed, and confirmed by experiment, that the human organism produces 1.5 calories per hour for each kilogramme of the body's weight. This corresponds, for a man of average weight, to 2,500 calories in 24 hours—a calorie being the quantity of heat required to raise the temperature of a kilogramme of water 1 deg. C. An equal quantity of heat must be given off by the body. Heat is lost by radiation and evaporation, through the skin and lungs. It is also converted into work, for, as heat may be generated by work, so may work be produced by heat. According to the mechanical theory of heat one calorie, or heat unit, is equivalent to 424 kilogramme-meters of work, or the work involved in raising 424 kilogrammes through a height of one meter. In 24 hours the human heart generates 208 calories, which would correspond, if entirely converted into work, to 88,272 kilogramme-meters.*—From the German of Dr. Adolf Heilborn in Für alle Welt.

THE STENOPHILE.

1. General view of the machine. 2. Details of the keyboard. 3. The paper ribbon. 4. Details of the ribbon-winding mechanism, showing reading frame. 5. Manner of using the machine.

A NEW STENOGRAPHIC MACHINE.

THE new stenographic machine, called the "Stenophile," illustrated herewith, has the advantage over others in that it writes in ordinary letters that can be read by any one at first sight. The difficulties of manuscript stenography are due especially to the complication of the signs, which become distorted in rapid writing so that the reading thereof is almost always impossible to anybody except to the person who has written them. On the other hand, the writing machine owes its wonderful development to the perfect legibility of its characters. These considerations led M. Charles Bivort, the inventor of the machine under consideration, to base his system upon the application of printed characters, and his method upon syllabic writing. After decompounding several thousand words and dividing the sounds, he succeeded in devising a rational practically combined alphabet. This alphabet not only facilitates the rapid and often textual composition of the majority of the words of the French language, but also of all the languages of Latin origin,

* In other words, the energy supplied daily by food may be computed either as work or as heat. For a normal diet, it has been estimated at about 1,000,000 kilogramme-meters, or 2,300 calories. The external mechanical work, at ordinary labor, is one-fifth or one-sixth of this, or about 150,000 kilogramme-meters. All the rest leaves the body in the form of heat. The actual *work* of the heart is estimated at 75,000 kilogramme-meters, but this and all other internal work is converted by internal friction, etc., into heat, and leaves the body as such. These data are from Foster's Physiology.—Editor.

and even, with certain rare exceptions, of the majority of other languages. The following is the order:

S J B P F V C K B M D T N L R H I A U E O.

The inventor then did away with the letters having the same consonance, to wit: C pronounced like S or K; Q pronounced K; X pronounced C S; Y pronounced I; and Z pronounced S. In this alphabet, the E represents é and è. The mute e is elided. On the contrary, he has added a second letter, I, in order to represent the sounds IO and OI, and the letters L, N, R, and S as the oftenest used finals.

It is upon such principles that M. Bivort has constructed his machine, limiting the number of keys to twenty, or ten for each hand. He thus had to reduce the number of the letters by doubling those of the same consonance, the B and P; F and V; Q, K and G; and D and T. The machine is conceived and constructed upon an entirely new plan. It in nowise resembles the writing or stenographing machines that have appeared up to the present, as regards mechanism, external appearance, or the results obtained.

The keys are placed in two rows corresponding to the five fingers of each hand. The letters inscribed upon the keys follow one another in a methodical order that permits of writing, at each stroke, a syllable or even words of several syllables.

The hands are separated by two intermediate keys, one of which writes the letter H, and the other causes the paper to move forward.

An accessory key transposes the letter keyboard for the writing of figures and conventional signs, thus doubling the number of the characters.

In order to reproduce the characters of any foreign language, it suffices to replace, upon the same type of machine, the transposing carriage that carries the engraved character. The velocity of the machine is limited only by the skill of the operator, and the rapidity has no effect upon the distinctness of the writing, which remains legible even beyond 200 words a minute.

Learning how to manipulate the machine is facilitated by the inscription of the letters upon the keys. According to the inventor, a tyro, after a few days' practice, can write 50 words a minute, and in less than two months will be able to attain a speed of from 125 to 150 a minute. The reading of the paper ribbons and the transcription by the type-writing machine are facilitated by the "reading divider" shown in Fig. 4.

As accessory advantages it is pointed out that the blind will thus be able to correspond in printed writing with those who can see, and thus be able to act as stenographic secretaries for them.

By applying this mechanical stenography to the telephone, it would be possible to preserve a visible record of verbal communications. In business houses or banks, it would be possible to dictate a report or a letter to the typewriter, who would begin as usual by stenographing under dictation, but with peculiar and improved facilities for doing so. Generally speaking, it would seem as if this new machine ought to greatly simplify the study of stenography. But it must not be forgotten that, as in all stenography, the latter requires a second operation to make it legible and consequently the purchase of a writing machine.—Translated from La Nature for the Scientific American Supplement.

LIQUID FUEL FOR NAVAL AND MARINE USES.*

By Rear-Admiral George Melville, Former Chief Engineer, United States Navy.

During my sixteen years of service as engineer-in-chief of the United States navy, no factor in warship design impressed me as of more importance than that of the boiler, the vital element not only in mobility, but in the many diverse mechanisms which, in the aggregate, constitute offensive power.

When nearing the end of my incumbency of this office I stated in my official report of June 30, 1902:

"The present problem of the modern battleship is not that of the gun and its mount, but the boiler and its installation. The gun is mounted in the most favorable position for care, operation, and inspection, and practically everything on board ship is subordinated to its efficient working. Since a large factor of safety is given to every part of the weapon that is subjected to shock, the gun can only be impaired by incompetence, neglect, or by chemical action of the explosive. Before it is placed in a turret or redoubt it is fully tested, but it is never put on board ship if there is a suspicion that it has been subject to undue strain.

"The boiler, on the other hand, is placed beneath the protective deck just above the bilges and near the bunkers. It is installed in compartments that are avoided rather than sought by other than engineer officers. While a careful test is made of the structure before being placed in the vessel, it must necessarily be subjected, even before installation, to conditions that often impair its strength. In its construction many of the plates are subjected to the severest kind of flanging, and its efficient inspection is much more difficult than that of the gun. As there has been a progressive demand for increased steam pressures, the factors of safety used in designing a marine boiler are progressively becoming smaller. The conditions under which the boiler is operated necessarily cause some of the parts to be subjected to rapid corrosion, and only incessant care and attention can prevent the disablement or rupture of the structure.

"While the warship may be nothing more than a gun platform, it requires considerable power to move a platform of 14,500 tons at a high speed in a heavy sea. This platform is not only expected to be maneuvered rapidly, but to steam uninterruptedly for a distance of one-fourth the way round the world. The battleship that can not make the enemy's coast the first line of defense is limited in the field of its usefulness, and when operating at such distance the value of the boiler factor comes only second to the value of the factor of the gun.

"The efficiency of the warship of the several naval powers is simply proportionate to the efficiency of their boilers and the character of their personnel. Neither in armor, armament, nor machinery is there any vital difference between the battleships of the several nations. In these respects, the last ship, wherever designed, is the best, for as regards draft, tonnage, thickness and extent of armor, character and distribution of guns, and design of machinery, every nation has settled upon a type of vessel that meets its particular requirements, and each navy has therefore secured the best warship for its particular purpose."

With these views it is unnecessary for me to say that the subject of liquid fuel has been one of deep interest to me and that it is with me a matter of much gratification that, during my incumbency, there were conducted an extended series of tests, which, in their completeness, time expended, and cost incurred, exceeded by far the largest outlay ever made by either private, corporate, or official interest in the investigation of the problem of determining the possible future field for crude petroleum as a fuel and its availability for naval and marine purposes. The officers entrusted, at my request, with this research were Commander John R. Edwards, U.S.N., Commander Whyte M. Parks, U.S. N., and Commander Frank H. Bailey, U.S.N. Their work was, throughout, of such a high standard and its results are so commendable in their accuracy and completeness that it gives me pleasure to record their names here.

In treating the subject of liquid fuel, upon which I have been asked to present a paper before this Congress, I feel that I cannot give, within the free limits assigned, a more effective review of the subject than in the form of a *résumé* of some of the important points covered by the report of this board, especially as this investigation was instituted by my orders and carried on under my general supervision.

The Hohenstein water-tube boiler used during these tests was of the straight large-tube type and was built to conform to the requirements as to weight, capacity, and the space occupied by one unit of the boiler installation of cruisers of the U. S. S. "Denver" class. Each of these units is required, under forced draft of one inch water pressure and under 275 pounds steam pressure, to evaporate 12,000 pounds of water per hour under actual steaming conditions, which, on the basis of 16 pounds of water per indicated horse-power hour, corresponds with about 15 indicated horse-power per hour per square foot of grate surface. The general dimensions of the test boiler were:

Drums.—There are six steam drums, forming a double hollow parallelopipedon. There is a front drum 24 inches in diameter; a rear drum 24 inches in diameter, and four connecting drums, each 16 inches in diameter. There is also a lower rear mud drum 24 inches in diameter.

Tubes.—There are 16 four-inch tubes 7 feet long, 384 2-inch tubes 9 feet long, and 15 5-inch downtake tubes, which are connected to the rear steam drum and to the mud drum.

Heating and Grate Surface.—There are 2,130 square feet of heating surface and 50.14 square feet of grate surface. Ratio of heating surface to grate surface, 42.5 to 1.

Volumes.—Water at steaming level, 142 cubic feet; steam-space, 50 cubic feet; furnace volume above grate bars, 121.14 cubic feet.

Ratios.—Area of grate to area of air space (average for all the tests with coal) 1 to 0.57; smoke-pipe area to grate area, 1 to 5.75.

The boiler was erected in an airtight steel structure built for these tests. The equipment comprised air-compressors, pumps, blowing engines, and all necessary scales, gages, and instruments of precision. Upon the completion of the coal tests and preparatory to beginning those with oil, an asbestos lining was put underneath the fire-brick of the furnace floor, a cylindrical tank boiler was installed for furnishing steam for spraying purposes, and a new compressor was fitted capable of delivering air at a very high pressure for a spraying medium. Provision was also made for introducing, during some of the tests with oil, additional air at the sides of the furnace. Holes 8 by 1 to 1½ inches were cut through the side walls on a level with the furnace floor and close to the back wall. A flue was built of loose fire-brick across the furnace floor, thus connecting the two openings. The roof of the flue had openings between the bricks, thus permitting extra air to be introduced where the combustion was most intense. The extra air supply was cut off during the natural draft and the maximum forced draft trials.

Character of the Oil Used.

While the bureau received many offers from various sources to furnish oil free of cost at the wells, careful inquiry showed that there was no certainty when this oil could be delivered at the experimental plant. Since time is a great element in the matter, the board deemed it necessary to use means whereby a steady supply of oil would be assured and no delay ensue from a lack of liquid fuel in the storage tank. The Texas oil was therefore secured from the Standard Oil Company, and the California oil through the personal efforts of Dr. C. T. Deane and Col. W. M. Bunker.

The oil used during most of the experiments was from the Beaumont, Texas, field. It is said to have been subjected to an inexpensive treatment which removed the sulphur and some of the more volatile hydrocarbons. The board believed that it would be best to use an oil that had been thus treated until some positive information could be secured as to whether or not it was safe and advisable to attempt to use crude oil.

Chemical Composition of the Oil Used During Tests Compared with the Crude Product.

The character of the oil used during the official tests can be best appreciated by comparing it with the average grade of the crude product. The changes wrought by the refining process can thus be clearly seen by comparing the analyses of the crude Beaumont product and that used in the experiments.

Analyses of Beaumont Crude Oil.

	Per cent.
Carbon (C)	84.60
Hydrogen (H)	10.90
Sulphur (S)	1.63
Oxygen (O)	2.87

The amount of sulphur in different samples of the crude Beaumont oil varies from to 2 to 3 per cent.

Calorific value per pound of combustible B.T.U.	19,060
Specific gravity	0.924
Flash point, deg. F.	180
Fire point, deg. F.	200

On distillation at atmospheric pressure to 524 deg. F. it was found that the

	Deg. F.
First 10 per cent passed over below	428
Second 10 per cent passed over between	428 and 485
Third 10 per cent passed over between	485 and 524
Fourth 10 per cent passed over between	524 and 554

Analyses of Beaumont Oil Used by Liquid Fuel Board as Determined by the Chemist of the Navy Yard, New York.

On distillation at atmospheric pressure to 680 deg. F. it was found that with the oil used during the tests.

	Deg. F.
First 10 per cent passed over between	216 and 482
Second 10 per cent passed over between	482 and 523
Third 10 per cent passed over between	523 and 552
Fourth 10 per cent passed over between	552 and 680

This oil showed on analyses to be composed of the following constituents:

	Per cent.
Carbon (C)	83.26
Hydrogen (H)	12.41
Sulphur (S)	.50
Oxygen (O)	3.83

The sulphur was determined by oxidation with fuming nitric acid in an open capsule.

Specific gravity at 60 deg. F.	0.926
Flash point, deg. F.	216
Fire point, deg. F.	240
Vaporization point, deg. F.	142
Loss for six hours at 212 deg. F, per cent	21.65

The calorific value of the combustible calculated on the analyses of the United States chemist by Dulong's formula, viz.:

British thermal units $= 14500C + 62100 (H - 0/8) = 19481$.

The analyses show that nearly all the sulphur was removed from the crude petroleum.

Analyses of the California Oil Used by Liquid Fuel Board as Determined by Chemist, Navy Yard, New York.

The sample consisted of high boiling hydrocarbon compound with a small amount of water, and has the ultimate composition:

	Per cent.
Carbon	81.52
Hydrogen	11.01
Sulphur	.55
Nitrogen	6.92
Oxygen	6.92

It gives the following constants:

Calorific value by Parr's calorimeter, B.T.U.	18,667
Specific gravity at 60 deg. F.	0.966
Vaporization point, deg. F.	230
Flash and burning point, deg. F.	311
Loss for six hours at 212 deg. F. per cent	12.20

Analyses of Residuum Mixture of California and Texas Oils.

The oil used during tests Nos. 68 and 69 were the dregs of the tank, and consisted of a mixture of the California and Texas product.

As it has been maintained by some experts that trouble would be encountered in using this mixture, special observation was made as to the manner in which it would burn.

It would also be a matter of interest to consumers of oil to note the evaporative efficiency of such fuel. An analysis of this mixture as made by the chemist at

* Paper presented before the Congress of the Permanent International Association of Navigation Congresses.

the navy yard, New York, gave the following results:

	Per cent.
Carbon	84.35
Hydrogen	11.33
Nitrogen	.60
Sulphur	.90
Oxygen	2.82

On distillation the following percentages passed over:

	Per cent.
Between 400 and 450 deg. F.	8
Between 450 and 580 deg. F.	12
Between 580 and 600 deg. F.	30

It has the following constants:

Calorific value by Parr's calorimeter, B.T.U.	19,215
Specific gravity at 60 deg. F.	0.966
Vaporization point, deg. F.	130
Flash point, deg. F.	270
Burning point, deg. F.	280
Loss for twenty-four hours at 212 deg. F., per cent.	14.90

Oil Burners.

The limits of space forbid other than brief, general descriptions of the oil burners used. For details, reference may be had to the report of the liquid fuel board.

Oil City Boiler Works Burner.—This burner is of the atomizer type. Oil escapes from a central tube through a small orifice and is swept off and atomized by steam or air from a concentric pipe. Six burners, spaced 18 inches apart, were ranged across the front of the furnace, there being a separate opening in the furnace walls for each burner. Considering the burners as arranged in three pairs, those of each pair were inclined toward each other at such an angle that their flows infringed near the transverse center line of the furnace. The details of the installation differed in various tests.

Hayes Hydrocarbon Burner.—The oil escapes from a central tube, through a small orifice, into a concentric tube fed by a steam pipe and thence flows diametrically across and through the outer wall of a pipe filled with air heated by the furnace. It is contended that the hot air in this pipe will cause the oil to be completely gasified before it escapes from the burner orifices. The installation comprised six burners. The steam oil pressures for the burners were, respectively 90 and 80 pounds.

The "Fill Reed" Combined Air and Steam Burner.—The oil escapes from a central tube into a concentric tube filled with steam and the mixture flows through an inclosing semi-globular passage into which the air enters. The Board gave its opinion that burners requiring both air and steam, apart from any question of furnace efficiency, prove unsatisfactory.

The "Harvey" System.—In this process, the attempt is made to separate the volatile and solid constituents of the oil product and then burn both the volatile and heavy portions of crude oil simultaneously by forcing the heated gas residuum to the burners at equal pressures. The system is typical of those shown by a large number of patents. The specific purpose set forth in this Harvey patent is to pass heated air through crude oil and thus take up a definite portion of the explosive gases of the product. No particular value is attached to the design and character of the burner.

The "Branch" System.—The guiding principle of this system is based upon the belief that there should be superheating of the oil fuel as well as of the steam or air used as the atomizing agent. The oil heater consists of two concentric cast iron cylinders between which there enters the exhaust steam from the various pumps of the installation. The inner cylinder thus forms a receptacle for the oil before being pumped to the burners. The latter are considered as but a very small determining factor in the use of oil as fuel. The type employed during the tests consisted of a central tube for steam or air and a concentric tube into which the oil entered, there being a small orifice at the outer extremity of the inner tube and a similar but larger orifice at the outer tube and just in advance of that for steam. In averaging the installation a reduction was made in the volume of the furnace and combustion chambers by filling the lower part of the furnace with earth to a level of about 5 inches.

"Advance" Burner.—In this system, the oil escaped through 1-32-inch holes in a nipple surrounded by a casing into which steam or air was fed. The burner orifice was rifled. The jet produced was of small diameter and great velocity. The burners were difficult to ignite and required constant attention. An improvement was effected, however, when the pressure of the steam was reduced and that of the oil increased.

Santa Fe or "Booth" Burner.—This is a slot burner used extensively on the locomotives of the Santa Fe railway system. The oil issues from the upper rectangular slot and steam from a passage of the same width, but of much less depth immediately below. For tests of this burner, a checker work brick flash wall with a 9-inch overhang was fitted in the furnace. The air requisite for combustion was admitted just in front of the flash wall through an opening 8 inches long, after passing under a raised floor of brick tile. This arrangement had the effect of partially heating the air before admitting it to the furnace.

The "W. N. Best" Burner.—This burner is of the slot design, the atomizing slot being above the oil supply passage. This arrangement is supposed to prevent the accumulation of carbon in the oil slot. By thus siphoning the oil, in a uniform manner, from its supply channel and having a high velocity of the atomizing agent, the separation of the particles of the liquid fuel can be satisfactorily effected and complete combustion secured. Both steam and air were used as atomizing agents. Only four burners were supplied for the test; six would probably have given better evaporative results.

Results of the Tests.—There were conducted a total of 69 tests of oil as fuel. The general results of the more important trials are given in the appended table.

Type of installation with Best burner.	Evaporative efficiency per pound combustible.	Evaporation per square foot of grate surface.	Total evaporation.	Degree of smoke.
Harvey	14.00	261.7	13,120	0.50
Best	13.51	314.8	15,787	0.52

As of especial interest, however, the following may be noted.

"Harvey" System.—Probably the best way of showing the results secured with the Harvey system during two tests under natural draft conditions is to compare results obtained with those secured during the two natural draft tests with the "Best" burner without such installation.

A cursory study of these results will show that with the Harvey process there was slightly increased evaporative efficiency over the Best burners, but with a decreased consumption of oil. It need only be stated that with every efficient type of oil burner probably some improvement as regards evaporative efficiency per pound of combustible can be secured in a water tube boiler by decreasing the evaporation per square foot of heating surface.

"Branch" System.—There were six tests made of this equipment with the following evaporative results:

Test Number.	Evaporative efficiency per pound of combustible.	Evaporation per square foot of equivalent grate surface of furnace for coal burning.	Total evaporation.	Air pressure in fire-room.
23	13.11	330 8	16,584	0
24	11 50	458.5	22,982	2
25	11.57	451.8	22,655	2
26	11.20	404.5	20 281	2
27	11.40	476.5	23,893	2
28	11.77	452 0	23,661	2

The above data will show that fairly good efficiency results were secured when the boiler was not forced. In the first test the boiler was run under natural draft, while in all the other tests was a 2-inch pressure of air in the fire room.

Booth Santa Fe Burner.—With this burner, the Texas oil gave better results than that from California.

General Summary of Data of the Tests.

Test No.	Date of test.	Duration of test.	State of weather.	Steam pressure per sq. in. (corrected).	Pressure of superheated steam used for atomizing per sq. in.	Pressure on oil feed line per sq. in.	Draft pressure of water in fire room.	Area of draft opening into furnace.	Air used for combustion per minute.
		Hours.		Lbs.	Lbs.	Lbs.	Ins.	Sq. in.	Lbs.
46	April 9	8	Clear and warm.	269.5	90	9.0	0	612	564
47	Do. 10	4	Do.	271.5	90	9 0	1	612	982
48	Do. 17	6	Do.	273.5	90	10.6	0	612	507
49	Do. 18	4	Do.	273.5	90	11.0	1	612	1,008
50	Do. 20	3	Cloudy.	273 5	90	10.0	3	612	1,900
51a	Do. 21	2	Clear and warm.	268.5	90	23.6	3	316	915
51b	Do. 21	2	Do.	268 5	90	23.0	3	508	1,473
52	Do. 22	2	Do.	267.5	90	23.0	3	316	908
53	Do. 23	2	Partly cloudy.	262.5	90	25.4	3	652	1,875
54	Do. 24	3	Clear and warm.	265.5	90	75.0	3	612	1,852

Test number.	Temperature. Outside air. Wet bulb.	Temperature. Outside air. Dry bulb.	Temperature. Superheated steam for atomizing.	Temperature. Chimney gases at base of stack.	Temperature. Feed water entering boiler.	Percentage of moisture in steam.	Height of barometer.	Weight of steam used for atomizer per pound oil atomized.
	°F.	°F.	°F.	°F.	°F.		Ins.	Lbs.
46	64	78	334	402	119	1.60	29.94	1.18
47	65	88	375	578	120	1.64	30 09	60
48	63	81	334	487	120	1.93	29.77	1.17
49	65	84	352	535	119	1.71	29.79	77
50	69	84	378	743	117	1 87	29.66	64
51a	61	83	367	665	120	1.87	29.70	44
51b	61	83	361	780	123	1.97	29.70	67
52	59	78	362	767	120	2 03	29.81	59
53	57	76	3'6	788	120	1.86	29 94	52
54	62	86	374	867	120	1.97	30 05	57

The following table shows the evaporative efficiency per pound of combustible, the evaporative capacity per square foot of grate surface, and the total evaporation secured per hour during the nine official tests conducted with the Booth burner. The results are calculated from and at 212 deg. F.:

No. of test.	Evaporative efficiency.	Evaporative capacity per square foot of grate surface.	Total Evaporation.
46	13.39	192.2	8,301
47	12.82	335.3	16,813
48	12.88	195.7	9,811
49	12.10	314.6	15,771
50	11.19	447.7	22,448
51	10.29	297.5	14,917
52	10.14	278.8	13,979
53	9.52	251.0	12,585
54	9.62	303.5	15,201

W. N. Best Burner.—The following summary of the tests made with this installation shows that the system is probably one of the best that could be fitted to a boiler for either natural or forced draft conditions. The general installation as much as the special form of the burner was responsible for the satisfactory results secured.

Test No.	Draft pressure in fire rooms.	Evaporative efficiency.	Evaporation of water per hour per sq. ft. of equivalent grate surface.	Total evaporation per hour.
	Inches.		Lbs.	
29	2	11.60	471.9	23,662
30	1	12.33	416.3	20,875
31	3	11.85	587.3	29,452
34	0	13.46	304.2	15,252
35	1	12.37	422.8	21,199
36	2	11.92	467.3	23,428
37	3	11.23	518.9	26,018
38	0	13.57	325.5	16,322

Oil City Boiler Works Burner.—The following summary of comparative tests made with Texas and California oil, when using the Oil City Boiler Works burner, will prove of interest.

Character of oil.	No. of experiments.	Air pressure in fire room.	Evaporative efficiency.	Evaporation per square foot of equivalent grate surface.	Total evaporation.
Texas	11	0	13.80	271.1	13,288
California	4	0	12 73	242	12,145
Texas	3	1 11	12.17	427	21,548
California	2	1	11.95	363.4	18,220
Texas	4	2 09	11.05	532	25,283
California	3	2	11.47	433	31,760
Texas	2	3.72	11.30	667	33,262
California	3	3	11.20	554.9	27,822

In some of the oil fuel experiments there were extensions in widths to the bridge wall whereby the volume of the furnace and the equivalent grate surface were somewhat reduced, the board believing that the several inventors should have pretty free scope in this respect. The equivalent grate surface actually represents the horizontal surface that could have been utilized to burn coal had grate bars been in place and coal used as fuel. The figures given are approximately correct.

These results would seem to show that when using this particular design of burner, both from the standpoint of economical efficiency and of capacity, the Texas oil has some superiority over that of the California product. The Texas oil, however, which was used at the experimental plant had undergone a greater degree of distillation, and as the Oil City burner had been particularly designed for burning the lighter product of the Pennsylvania and Ohio yield, it was to be expected that the device would operate better with a distillate from the Texas wells than with a crude product from California. The comparison shows that while with a good form of burner satisfactory results, as regards efficiency, can always be obtained with any kind of oil as a fuel, it is essential to modify the details of construction of burners using a heavy or light crude oil.

A fairer comparison, however, as to the economical efficiency and the capacity of evaporation of the oil products of California and Texas may be made by comparing the results obtained with the Oil City burner when using Texas oil with the Best burner using the California product.

In comparing the performance of what may be regarded as two excellent forms of burners, and both well adapted for marine and manufacturing purposes, it should be particularly observed that there was an installation of only four burners of the "Best" design as compared with six burners of the Oil City type.

Comparison of Results with an Eastern Burner Using Texas Oil, and a Western Design of Burner Using California Oil.

The following comparison shows that, under 1-inch forced draft conditions, practically the same efficiency and capacity results were secured with the two burners when using differing oils. Under natural draft conditions the advantage was with the "Best" burner and with California oil. Under 2-inch draft conditions the advantage was with the "Eastern" burner and Texas oil. The general results of these three different characters of tests show that the burners are undoubtedly about equal in efficiency and that there was but little difference in the value of the oil from the two localities as measured from the standpoint of weight.

In regard to the maximum draft tests, it appears that the decided apparent advantage as regards the capacity evaporation in favor of the Texas product can be accounted for by the fact that a higher fire room pressure was used when the Oil City burner was in use, and that 50 per cent more burners of this design were in operation. If measured by the standard of number of burners in use, the advantage is with the California oil.

In general it may be stated that it is exceedingly

Type of Burner.	No. of tests.	Air pressure in fire rooms.	Evaporative efficiency.	Evaporation per sq. ft. of equivalent grate surface.	Burners in operation.	Total evaporation.	Oil.
Oil City......	11	0	13.80	271.1	6	13,298	Tex.
Best........	2	0	13.52	315	4	15,787	Cal.
Oil City......	3	1.11	12.17	427	6	21,548	Tex.
Best......	2	1	12.35	419	4	21,037	Cal.
Oil City......	4	2.09	11.05	532	6	25,293	Tex.
Best......	2	2	11.76	469.6	4	23,545	Cal.
Oil City......	2	3.72	11.30	667	6	33,262	Tex.
Best......	2	3	11.54	553	4	27,765	Cal.

probable that for maximum forced draft purposes the greatest evaporation can be secured from the lighter oils, due to the fact that the oil supply can be more uniformly regulated.

(To be continued.)

AN EXPERIMENTAL GEOLOGICAL COLLECTION.

The imitation of geological phenomena by means of various experimental arrangements is very differently regarded by different men of science. Some geologists deem it capable of solving almost all the problems that lie buried in the earth, while, in the opinion of others, such experiments are only scientific amusements or tricks. As usual, the truth is found between these extreme views. It is a curious fact that this truth has never been formulated. It is this: Experimental geology corresponds, in scientific value, to the lecture experiments which are so much in favor in the teaching of physics and chemistry. Geology—at least, as it is usually taught—is a dry subject, which needs to be "vivified" by concrete and impressive examples. It is best studied in the field, but field study often presents many and even insuperable difficulties. In such cases, geological excursions may be replaced by experiments which can be performed before the class and by others, made in preceding years, of which the results may be shown to the pupils. A collection of the most interesting experiments has been arranged and exhibited by M. Stanislas Meunier in the geological department of the Paris Museum of Natural History. By way of example I will describe briefly a few experiments which imitate geological phenomena due to external causes, particularly the denudation effected by running water.

FIG. 1.—IMITATION OF "FAIRY CHIMNEYS."

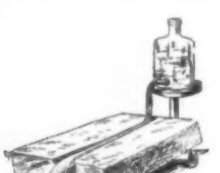


FIG. 2.—IMITATION OF FORMATION OF VALLEYS.

If artificial rain from an ordinary watering pot with a "rose" nozzle is allowed to fall on a mixture of earthy particles which differ in size, shape or weight, it is soon observed that each class of particles is affected differently from the others. The small and light grains are first carried away and the heaviest particles resist the longest. Flat splinters of rock, lying horizontal, perform the function of roofs so that they soon become the entablatures of little columns of earth precisely similar in form to natural "fairy chimneys" (*cheminées des fées*). The study of these little specimens is of great interest in connection with the view to be adopted of the mechanism of sub-aerial denudation and in regard to the grand phenomenon of the formation of valleys. From this point of view, especially, it is of interest to note that "fairy chimneys" can be produced only by nearly vertical rains and that they cannot exist in the presence of an abundant flow of water over the surface. The smallest transverse stream disintegrates and destroys them, so that their presence on the flanks of certain valleys in mountainous regions (at St. Gervais in the French department of Haute-Savoie; at Ritton, near Bauzen, on the Finsterbach; on the Zuni plateau in New Mexico) proves conclusively that these valleys, contrary to the opinion often expressed, are not the work of torrents or large streams, but have been slowly chiseled out by rain.

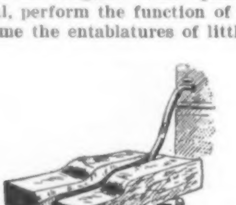


FIG. 3.—IMITATION OF RETROGRADE MOTION OF CATARACTS.

M. Stanislas Meunier observes that the utility of experimentation is shown in this case by the precision given to the conditions of the phenomenon.

FIG. 4.—IMITATION OF LATERAL TERRACES OF RIVERS.

On a horizontal or nearly horizontal surface the effect is *nil*, because of the accumulation of water at the feet of the little columns of earth, and on a steeply inclined surface the columns cannot withstand the action of the swift rivulets of escaping water.

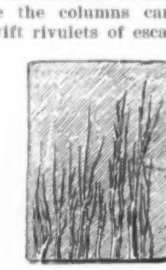


FIG. 5.—IMITATION OF WATER COURSES.

A moderate inclination is necessary and the best angle appears to be from 35 deg. to 40 deg., about equal to the natural slope of a mass of loose material. This fact suggests the notion of a period in the formation of valleys in which, alone, these earth columns can be produced and of which they are characteristic.

Fairy chimneys, furthermore, are not usually produced by watering any chance medley of materials. If the larger fragments are not flat and if the rain falls obliquely or if (as is very often the case) the earth does not possess sufficient cohesion, these fragments are undermined and they sink vertically, while the fine particles are gently washed away by the rivulets.

Some peculiarities of water courses can also be imitated without difficulty. For example, gorges can be produced by allowing streams of acidulated water to fall on slabs of limestone. A stone easily affected by acid, such as the soft limestone of the environs of Paris, and a one per cent or two per cent solution of hydrochloric acid should be used. The flow of liquid and the inclination of the stone are varied according to the result which is desired. It should be observed that the chemical action which is here employed is subject to the same laws as the mechanical effect of torrents. This is proved by the absolute conformity of detail presented by the gorges produced by the two methods. It should not be forgotten, however, that the water of torrents exerts some chemical action on many rocks.

FIG. 6.—IMITATION OF MEANDERING STREAM.

If, instead of a flat stone, one with a sort of ledge or terrace in the middle of its length is employed in this experiment, we obtain an imitation of the retrogression of a cataract, like that of Niagara. Under the influence of the constant stream of water the cascade is actually seen to move backward, or in a direction opposite to the course of the current.

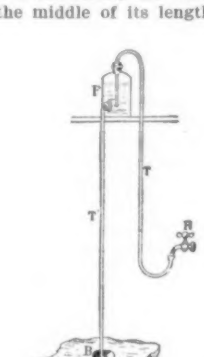


FIG. 7.—IMITATION OF NATURAL WELLS.

This experiment is well adapted to show the retrogressive character of all the peculiarities of fluvial erosion which results from the vertical action of streams of water. This condition is contrary to that presented by the effects of the horizontal action of the same agents, for the latter are essentially progressive, that is to say, they travel with the current, or down stream.

Now, suppose we replace the cylindrical efflux pipe by one which is flattened horizontally at the end and allow the fan-shaped stream thus produced to fall upon an inclined slab of limestone. In a little while we observe that the stream has become confined to the middle of the broad surface which it moistened at first. This is an example of the progressive contraction of streams flowing through plains which they erode, the result being the creation of lateral terraces along the banks. In the experimental imitation these terraces are especially well marked when the limestone consists of thin strata of varying constitution and different degrees of solubility, which prevent the erosion from proceeding at a perfectly uniform rate.

In order to imitate beds of streams traversing very steep slopes a shallow dish filled with a mixture of plaster and water is inclined at an angle of from 45 deg. to 60 deg. before the plaster has completely set. Water is then seen to drain off from the lower edge of the mass, at nearly equidistant points, from each of which springs a tree-like, much branched, and complex system of little furrows, which grows very rapidly, from below upward (Fig. 5). The result contains exact imitations of many natural details observed in mountainous regions as in the valley of the Rhone, on the slopes of Mt. Arvel, near Villeneuve, in Dauphiny, etc.

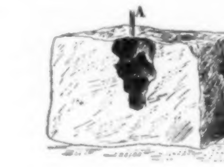


FIG. 8.—IMITATION OF FUNNEL-SHAPED WELLS.

A rectangular dish of glass or porcelain, such as is used by photographers, forms a suitable vessel. It must not be too small; 10 x 16 inches is a good size. The dish is first placed horizontally and filled to a depth of a third of an inch with the mixture of plaster of Paris and water. As soon as the mass has acquired the consistency of soft cheese the dish is inclined. The water at once begins to drain off. At first only the lowest parts of the little rivulets are visible, but they rapidly extend upward. In the course of their growth some of the streams are *captured* by others, thus reproducing certain geographical phenomena which M. Davis has described. In every part of this experiment phenomena are reproduced which are of great interest in connection with the history of valley formation and which also explain the origin of passes over mountain chains and the isolation from their points of origin of blocks that had drifted before the original continuity of the slope was destroyed.

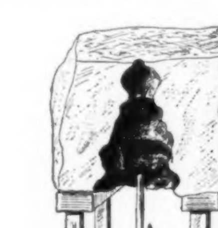


FIG. 9.—IMITATION OF CAVITIES SHAPED LIKE INVERTED FUNNELS.

An imitation of a meandering water course is produced by subjecting a mixture of wet plaster and sand to the action of an oblique stream of water (Fig. 6). Four parts of fine sand are mixed with one part of plaster and sufficient water to give the desired consistence, and the mixture is spread in the form of a flat cake on a thin board which is then slightly inclined. A caoutchouc tube which may be inclined at any desired angle to the line of greatest slope of the board supplies a stream of water which first touches the cake at the middle of its upper edge. The force of the stream is regulated by a cock, which enables the results to be greatly varied. With certain mixtures of sand and plaster and with a suitable inclination of the stream of water, the channel caused by erosion is seen

FIG. 10.—IMITATION OF NATURAL CAVERNS.

to move in the manner of a natural river bed. Before the water is turned on, the surface of the cake should be hollowed out into the form of a very shallow and broad gutter.

For the experimental reproduction of natural wells water mixed with a small known quantity of hydrochloric acid is allowed to fall on a block of limestone, in which it rapidly erodes a cavity. In practice the water flows from the service pipe to an elevated reservoir, F (Fig. 7) where the acid is added, and thence down a second tube, which should also be furnished with a stop-cock, to the limestone block. If the solution is weak enough the effervescence at the surface of the stone is very slight. Time is saved by using a stronger solution and it is interesting to vary the method of operation according to the effect desired.

Fig. 8 shows the result which is quickly obtained by operating in the manner described above. (The stone has been sawed through the axis of the cavity in order to exhibit all the details.) The general form of this cavity is seen to be that of a funnel, or a cone standing on its apex. The surface, however, is not smooth but is broken by well marked projections in the form of cornices or ledges, which correspond to the layers of different solubilities of which this (Paris) limestone is composed. This formation is very interesting because of the fidelity with which it reproduces the peculiarities exhibited by the walls of natural wells, as may be learned by a visit to a suitable locality, such as Ivry, at the very gates of Paris.

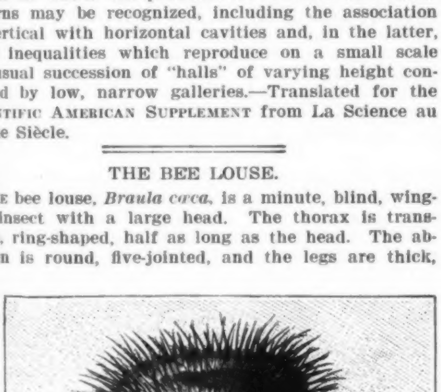
If, instead of terminating the experiment at this point, it is continued, the cavity gradually becomes deeper until the stone is entirely perforated. If the experiment is still continued, especially if the stone is placed on a bed of sand of sufficient porosity, then it will be observed that the perforation tends to increase in diameter at the bottom so that the tubular cavity tends to assume the form of a truncated cone standing on its large base.

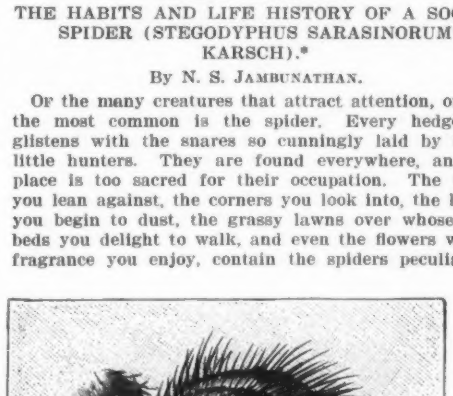
The arrangement shown in Fig. 7 may be slightly modified by bending the tube which conveys the acidulated water from the reservoir and directing the stream vertically upward against the lower face of the stone. The effect is, so to speak, symmetrical with that of the descending jet. Again we have a conical cavity but now the cone stands on its base and resembles an extinguisher rather than a funnel (Fig. 9). Now, this result is very interesting because natural cavities of these two forms are often found associated and the experiments indicate the different methods by which they have been produced. To cite a single example, the celebrated zinc mines of Laurium, in Greece, show funnel-shaped cavities in the walls of the schistose strata and inverted funnels at the roof, which agrees with the results of experiment.

Other experiments, of great value, may be made with artificial fissures in rocks; for example, about one-quarter of a rectangular block of limestone is cracked off with a hammer (Fig. 10). The two pieces are put together again but between them is left a wide fissure into which a stream of acidulated water is allowed to trickle. The acid excavates a shaft and horizontal canals in which the peculiarities of form of natural caverns may be recognized, including the association of vertical with horizontal cavities and, in the latter, local inequalities which reproduce on a small scale the usual succession of "halls" of varying height connected by low, narrow galleries.—Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from La Science au XXme Siècle.

THE BEE LOUSE.

THE bee louse, *Braula cæca*, is a minute, blind, wingless insect with a large head. The thorax is transverse, ring-shaped, half as long as the head. The abdomen is round, five-jointed, and the legs are thick,





FIGS. 1 AND 2.—THE BRAULA CŒCA ON THE LEG OF A BEE (HIGHLY MAGNIFIED).

with long claws that enable it to cling to the hairs of bees. The insect may be compared with the flea, its body being flattened vertically, while that of the flea is flattened laterally. The antennæ are short, two-jointed and sunken in deep pits. It is from one-half to two-thirds of a line long. Its larva is headless, oval, eleven-jointed and white in color. It is a body-parasite, one or two individuals occurring on the body of the honey-bee, though it sometimes greatly multiplies and is very troublesome to its host.

M. J. Perez has given some extremely interesting details in regard to the habits of the bee louse, and it was he that first made known its manner of feeding. He observed it on the front of the bee's head, moving about with great activity, striking and scratching the base of the labrum with its fore legs, then receding toward the insertion of the antennæ, and again making its way to the mouth and finally stopping there to sip a small drop of honey disgorged by the buccal organs of the bees.

This manner of living well explains why the *Braula*

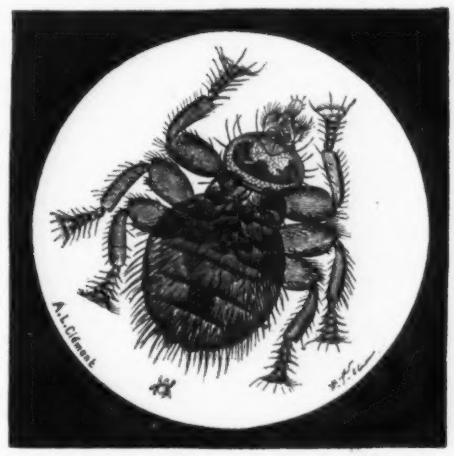


FIG. 3.—MICROSCOPIC PREPARATION (ENLARGED) OF BRAULA CŒCA.

Underneath, the insect is shown of natural size.

quickly dies when separated from its victim. Its metamorphoses are also very curious. The double oviduct of the female contains but four embryos, which develop therein completely and are nourished by an internal mammary gland. After expulsion they resemble a pupa. The hatching of the perfect insect takes place in a fortnight.

The *Braula* is very common in France, Germany, and the Baltic provinces (although it seems to be unknown in the rest of Russia) and, according to Langstroth, is found also in North America. Bee keepers consider it as a true parasite and destroy it. For this purpose it is recommended to dust the bees with incense powder, or to place pieces of naphthaline in the hive. A few puffs of tobacco smoke will cause them to let go their hold and drop to the floor of the hive whence they may be swept to the exterior. This method, however, should be used with prudence, since tobacco is deadly to bees when they respire its smoke in too great quantity.—Translated from La Nature for the SCIENTIFIC AMERICAN SUPPLEMENT.

THE HABITS AND LIFE HISTORY OF A SOCIAL SPIDER (STEGODYPHUS SARASINORUM KARSCH).*

By N. S. JAMBUNATHAN.

OF the many creatures that attract attention, one of the most common is the spider. Every hedge-row glistens with the snares so cunningly laid by these little hunters. They are found everywhere, and no place is too sacred for their occupation. The walls you lean against, the corners you look into, the books you begin to dust, the grassy lawns over whose soft beds you delight to walk, and even the flowers whose fragrance you enjoy, contain the spiders peculiar to each of these localities. Some there are that run, that spin, that dive, some that even dig to catch their prey; thus pursuing several of the various crafts and industries of men—spinning, weaving, diving, and mining. Some spiders seem to be successful aeronauts performing long journeys across mountains, rivers, gulfs, and seas—by means of their slender threads. These facts and many others concerning their extraordinary habits and intelligence have already been noted by man.

Simon, a French arachnologist, first hazarded the statement that some spiders exhibit a form of social living. This assertion I find questioned by that eminent American entomologist, the Rev. Dr. McCook, who maintains that "all spiders are solitary in their habits and that the discovery of a social species, if confirmed, would be most important. Males and females might be seen living amicably together for a considerable period, but this cannot be social living." (Vide

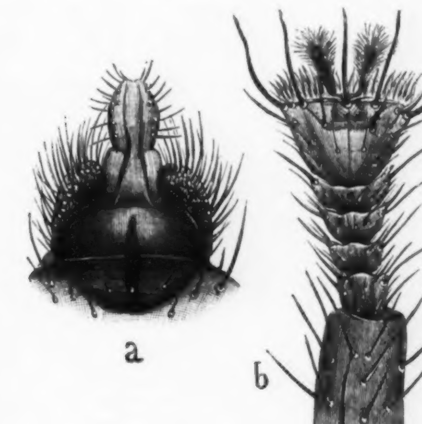


FIG. 4.

a, Mouth. b, One of the tarsi.

SCIENTIFIC AMERICAN, page 136, September 17, 1892.)

From this we may easily see that the question as to the existence of communal spiders is a debated one. My study of social insects generally led me to a closer investigation of the habits of the spiders of southern India, and in March, 1898, I discovered at Saidapet, Madras, a group which I believe may properly be termed "social spiders."

These spiders live in a sponge-like nest of ramified net-work of inter-communicative canals with a number of outside openings. The nests, often seen attached to the ends of the branches of trees or to leaves of the prickly pear, are ash-gray in color and made of dried leaves and refuse matter from their food, and are overlined with their thick, sticky threads, thus affording an advantageous background for the spiders, for being of the same color as the nests they are thus given necessary protection. Numbers of sheetlike webs radiate from the nest, in one or many directions. At a given spot five or six nests are often found built over the leaves of the prickly pear, with a number of connecting webs—thus establishing means of inter-communication. These hanging webs are peculiarly constructed. A number of strong and non-sticky threads are irregularly laid to form the warp, while the woof of sticky threads closely laid in a zigzag manner connects the non-sticky threads issuing in all directions, sometimes establishing communication between one nest and another, like bridges to cross the intervening space.

The number of spiders in a nest varies from 40 to 100. Males and females occupy the same nest in the proportion of 1 to 7, though sometimes the females are less numerous.

The creature itself is not less interesting than its nest. It is more or less a compact animal about the size of our ordinary vagrant spider of the family Attidæ.

THE FEMALE.

	Millimeters.
Total length cephalic thorax and abdomen.	8
Abdomen	4
Cephalothorax	4

THE MALE.

Total length	6
Abdomen	3
Cephalothorax	3

This spider belongs to the family Eresidæ. It is ash-colored, this tint being due to the color of the hairs over its body surface. Three longitudinal white stripes mark the dorsal surface of the abdomen. The limbs are striped gray and brown. A number of dark lines makes the abdomen appear segmented, but closer examination shows them to be only external figurations. There are approximately six pairs of dots arranged on either side of the leaf-like patch on its dorsal surface.

The ventral surface of the abdomen bears two black irregular spaces, the lower one of which contains the spinnerets, which are six in number, with a cribellum. The cephalothorax is ash-colored with an anterior prominence that forms the head. The cephalic groove which is well marked in most spiders is absent here. The eight eyes are arranged in three rows as in Lycosidæ. The first two rows, of four and two, lie in a black spot in front of the head, while the other rows are a little behind with their faces directed rather toward the sides of the animal. Thus the spider can see objects in front as well as at the sides. The falces are black, pointing downward, with the curved claws working sidewise.

In almost everything except in size and palpal organs, the male resembles the female, and although the male is the smaller, the measurements of the two do not show him to be the dwarfed individual found in

* Reprinted from Smithsonian Miscellaneous Collections (Quarterly Issue), vol. xlvii. Published March 2, 1905.

many species of spiders. In place of the black streaks and stripes of the female, we meet with brown ones in the male.

As already mentioned, the prickly pear bushes appear to be the favorite resort of these spiders, though sometimes the branches of some other thorny plants are preferred. A whole tree may be so covered with the nests, that the leaves are hardly visible. I have also found these nests on tops of hills. If built on the prickly pear, the leaves serve as bases or floorings. If on the ends of branches of trees, the leaves serve as partition walls or roofs for their silken dwelling, which is plastered and cemented by means of woven threads. In every case the refuse of their food serves as a convenient substance for thickening the walls of their nest.

The web is arranged in longitudinal and zigzag lines. If it is to be a horizontal sheet, a main line is made of the finest, strongest, yellowish silk-like threads with a luster all their own. This main line is laid by the joint labor of six or seven spiders moving over the line a number of times, thus thickening it, and making it not one thread but a bundle of threads. Other lines are laid, connecting with this main line in all directions. These may be of fewer threads, yet strong enough for their purpose. Having now finished the warp lines of the web, the process of regular weaving is begun. The spiders settling at different places begin to spin out their thick, smoke-like, sticky threads and to lay them as connecting lines for their web. The method of drawing out the thread is unique in the spider world. In almost all the web-builders the sticky threads as well as the non-sticky ones come out as the spider moves from one line to another, a method which may not be possible here, these spiders using their hind pair of legs, which are then seen moving in quick succession rubbing against the spinnerets. The threads so taken are laid without any regard to either precision or symmetry, the only object being somehow to fill the space and make a net. These transverse sticky lines, being eminently elastic, can be drawn out to ten times their ordinary length. While there is work to be done, there is no standing still, no idleness; each individual appears to recognize its own responsibility in assisting to complete the web. As soon as a spider finishes work in one spot, it hastens on to where the web is still incomplete, so that within two or three hours the whole task is finished. This done, the spiders retire to the nest to enjoy a well-merited rest. Like some other spiders, these are also nocturnal in their habits and begin web-building between the hours of six and seven in the evening, finishing their toil before eight or nine.

The manner of repairing the nest is also very interesting. The first spider that comes out of the nest after sunset sets to work to repair any damaged portion it may discover. It thus never becomes necessary to completely rebuild their webs. The burden of building and repairing webs falls heavily upon the females of this spider colony. They are the active workers. The males appear to do very little, though not wanting in apparatus necessary for web-building, since they may be observed, while young, actively participating in such a task. When they attain maturity, they think of nothing but courtship and love, and can then be seen moving about in the web, disturbing the females that are patiently engaged in their work.

With their nests and webs in shady places our spiders never suffer from want of food. Bees and mosquitoes, crickets and beetles, butterflies and moths in their pleasant flights entangle themselves in the waiting snares. The struggle of the victims sounds the signal that prey is available and the spiders hurry to the spot to pull and drag the victim to the nest. In this effort part of the web may be damaged. Spiders there are, in the family of Epeiridæ, that can skillfully disentangle a prisoner and carry it away without damage to their webs, but social spiders do not possess this skill.

The arrival of the victim is eagerly awaited by the spiders in the nest, ready to catch hold of some portion of the prey. Those carrying the precious booty never appear to resent the actions of others that pull the victim in all directions, before they finally settle down to partake of the food thus secured. Sometimes the spiders do not bring the victim to the nest, but begin eating it where caught. On one occasion an extreme case of selfishness came under my notice. A spider pulled hard at a victim, got a good piece of its leg, and ran away to a corner to feed unobserved by the others. But as a general rule they are seen partaking of the meal at a common table and nothing can be more curious than the sight of these spiders, almost one over another sitting at dinner, some feasting at the head, some at the body, some near the tail-end, others sucking their repast from the limbs of the victim. To test their intelligence I once threw a big ant into a web. As the ant struggled a spider issued from the nest in the direction of the prey, but found the creature too defiant to be easily pulled home. The spider caught one leg many a time, and many a time it ran for life, fearing the ant's bite. In a moment, another spider came to its aid, but, curiously enough, instead of catching hold of the ant, began to pull the first spider by its abdomen, until other spiders came to the rescue and the victim was carried away by their joint labor, to the common nest.

If such an ant were thrown into the web of an Epeiridæ, the victim, however big and ferocious, would be carefully bound by threads and thus secured. The social spiders know how to drag, pull and bite, but have never learned the finer and safer method of binding and securing their prey. Perhaps the extremely sticky character of the webs lessens the necessity for them to develop these finer methods.

In the foregoing paragraphs, two facts have been clearly recorded about the habits of this group of spiders, (1) the joint action and willing co-operation of a number of them to achieve a definite end, (2) the partaking by any and every spider that happens to get near it of the meal brought by one or more, the captors showing apparently no resentment. These two facts together with what has been noted in connection with web-building point to the conclusion that the spiders we are considering certainly exhibit a form of social living which is, so far as I am aware, rarely met with in the spider world.

It has been noted by every arachnologist that the relation between the sexes is something unique in spider communities. The male is generally a dwarfed individual, and is able to carry on his life's task only by agility and cunning. Such antagonism exists between the sexes, that a male seldom returns from courtship without losing a leg or two. It is a struggle which often imperils even his life. In some families, as in the Epeiridæ, this struggle has been so severe and lengthened that there have come to be certain profound modifications in the mental as well as the bodily structure of the males, they being often dirty-colored and dwarfed individuals, and hardly recognizable as spiders at all. In addition to this the male is sometimes caught and devoured by his savage consort.

But the picture is not all dark—all tragic. There are some families that exhibit a more genial relationship. In the Attidæ, Lycosidæ, Thomisidæ, Phalangidæ, Tetragnathidæ, and Mygalidæ, the males are nearly as bright colored and attain to almost the same size as the females. Here there is no danger to life, all the risk that a male runs being, perhaps, the loss of a limb or two. In everyone of the groups of spiders mentioned, the female and male may be seen near each other only during the pairing season and even then the male has to make its own arrangement for food.

Here the absence of much disparity in size and color between the sexes, the friendly and communal living of the males and females in the same nest, and lastly, the happy and almost affectionate relation that subsists between the sexes, indicate a high order of development. The savage nature of the female in other groups is never displayed by the female spiders of this group.

The female gladly welcomes her lover, and the male may be seen rubbing its pedipalps alternately against the genital pore of the female, sometimes for over three or five minutes. At other times one may find the male running after the other sex, in fact, hunting it through all the winding passages in the nest. The female may step aside, or run, and thus avoid the approach of the male, if she has no liking for such a meeting; but never does she exhibit the rancor and resentment with extended forelegs and well-drawn falces, found among the females of the family Epeiridæ.

The eggs when laid are packed in silk in a lenticular cocoon, which is white in color, and about six millimeters in diameter. Unlike the other spiders that carry the cocoon, either by means of their falces or spinnerets, the female in the group we are considering, attaches it to the side walls of the nest.

After a period varying from thirteen to fifteen days, the young ones try to emerge from the cocoon by tearing out portions of its walls. These little spiders, the size of an Indian mustard seed, move about and some of them settle over the back of the mother, after the manner of Lycosidæ. The abdomen of the young ones is globular and pink-colored. Until they pass through two or three moults, they do not appear to take any food. As they grow older, they partake of the food brought by the mother. I have often noted instances in which the females quietly retired, leaving the food they were eating to the young ones that clustered round it. After a few moults, the young spiders begin to participate, in their own little way, in the grand task of web-building. Small patch-works of webs, a few lines here and there, mark their juvenile efforts. At this stage no difference of size, color or sex is visible. The time required by the young spiderling to reach the adult condition, after issuing out of the egg, is almost three months.

While the development of the young is in progress, the adult members of the nest either desert it, one by one, to found, perhaps, new colonies elsewhere, or voluntarily starve themselves, or are starved to death by the rapacity and greed of the younger generation. In the nest at this stage I have found the young ones very active, while the members of the older generation were scarcely able to move. Later, I found only the dried remains of a few old ones to mark their former presence in the nest. Closer examination makes me strongly affirm that the dried remains are not the skins generally cast away after moulting, but the real bodies of the spiders shrunken and shriveled up. In some nests I have also found one or two members of the older generation living with those of the younger generation.

Like other creatures, these spiders are subject to the varying influences of heat and cold, and show in some instances remarkable powers of adjustment. Living, as they do, in the tropics, they have learned a method of protecting themselves from heat by building their nests mostly under the shade of trees. If ever they happen to be exposed to the direct rays of the sun, as was a nest which I purposely tied to a hedge in my garden, the inmates are seen outside the nest resting on the threads proceeding downward, the spiders being shaded by the nest. Evidently the heat between 11 A. M. and 4 P. M. in the interior of the nest must have been unbearable. Even when disturbed and driven within they would not remain inside the nest.

In winter the walls of the nest are thickened, especially in the upper part, which is exposed to the rainfall. The holes leading to the nest are to be found in the under surface, and those which might catch the wind are carefully closed. In spite of all these precautions, these creatures suffer like other animals during this season. They are able to protect themselves completely from neither wind nor rain, nor are they able to procure their food easily.

The area under my observation is limited to South India. So far as I have seen, and I have visited some of the typical districts—such as South and North Arcot, Salem, Coimbatore, Malabar, Chinglepu, Madura, Trichinopoly and Tanjore—this species is more or less universally distributed throughout these districts. On the top of the Tripati hills, in North Arcot, at an elevation of some five hundred feet above the sea, I saw their nests. Considering the facilities these spiders have for safe and speedy dispersal, one need not wonder at their wide distribution. The young ones may sometimes be detected while on their aerial voyages to near or distant places as the winds permit. At other times one solitary spider, more or less in the adult condition, ventures out and settles near the mother colony. At times a female, while in the act of web-building, may be carried away by the wind and thus plant a new colony.

Before concluding this description let me rehearse the points which lead me to designate this group of spiders as social. We note the common nest for a number of spiders—males and females; the manner in which they build and repair their nests; their feeding together, and the absence of ill-feeling among them—these are characteristics not commonly met with among animals of the solitary kind. Other points in their habits go to strengthen my conclusion. The relation between the sexes is found to be one of affection, and the maternal feeling for the offspring verges almost on self-sacrifice.

While it must be conceded that these spiders have nothing of that differentiation and organization found in the communities of ants and bees, it still seems that the amicable existence led by them in the common nest which has been built by united effort, the friendly sharing of their meals, the more than toleration, the affection shown for each other by the male and female, and the self-denial of the mother on behalf of her young entitle this group of spiders to be called social.

APPENDIX.

The author, who has given such an interesting account of one social spider seems unaware of records of various other species. Probably all the species of *Stegodyphus* are social. The Rev. O. P. Cambridge was the first to record this habit in this genus, when describing *S. gregalis* from South Africa. A nest of this species was kept for some time in the London Zoölogical Garden. Mr. Marshall has written an account of this species which agrees very closely with that of Mr. Jambunathan. He notes that several feed upon the same insect, and that the old ones die in the early winter. He also speaks of a mouse that nests in the midst of a communal nest to feed on the insects, and of a Tineid moth that breeds in the débris of dead insects. Simon has described several social spiders from Venezuela, notable among them being *Uloborus republicanus*. Mr. Schwarz has found this species in Cuba, and notes that the males keep to one corner of the connected mass of webs.

References to the social spiders are as follows:

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G. A. K. Marshall—Zoölogist (IV), vol. II, pp. 417-422, 1898.

L. Kathariner—Biol. Centrabl., XXI, pp. 72-74, 1901.

E. A. Schwarz—Proc. Ent. Soc. Wash., VI, pp. 147-148, 1904.

[N. Banks.]

ARTIFICIAL LIMBS IN ANTIQUITY.

The modern inventor has often enough occasion, adapting the curse to his own need, to cry "Pereant qui ante nos nostra fecere!" Even in surgery, which we had fondly believed to be nearly all our own, it is becoming clear that some at least of our improvements are old things with new names. What is known to modern dentists as bridge work was familiar to the Etruscans, as extant specimens attest; plaster ears, noses, and lips were common among the Indians, where the cutting off of these features was a punishment much in use; Nero anticipated the advice given to the converted æsthete, and "stuck an eye-glass in his ocular," and Greek and Roman veterans who had lost a leg or an arm in war tried to make good the deficiency by artificial substitutes. What is said to be the oldest artificial leg in existence is now in the museum of the Royal College of Surgeons of England. It was found in a tomb at Capua, and is described in the catalogue as follows: "Roman artificial leg; the artificial limb accurately represents the form of the leg; it is made with pieces of thin bronze, fastened by bronze nails to a wooden core. Two iron bars, having holes at their free ends, are attached to the upper extremity of the bronze; a quadrilateral piece of iron, found near the position of the foot, is thought to have given strength to it. There is no trace of the foot and the wooden

core had nearly crumbled away. The skeleton had its waist surrounded by a belt of sheet bronze edged with small rivets, probably used to fasten a leather lining. Three painted vases (red figures on a black ground) lay at the feet of the skeleton. The vases belong to a rather advanced period in the decline of art (about 300 years B. C.)" The earliest known representation of an artificial limb is on a Græco-Roman vase in the Louvre, where a satyr is depicted with a wooden leg. In a Græco-Roman mosaic a sportsman is represented with a wooden leg. Both these productions are believed to belong to the pre-Christian period. Pliny speaks of a Roman warrior who, a century and a half before the birth of Christ, wore an artificial hand with which he was able to handle a sword. In the Middle Ages artificial limbs sometimes repaired the disablements of war. The "iron hand" of Goetz von Berlichingen was an ingenious piece of mechanism made for that famous knight in 1504. A century later an artificial hand was worn by Christian, Duke of Brunswick. Ambroise Paré devised artificial limbs with movable joints which were made for him by artificers, of whom Lorraine, a locksmith, was the most famous. Paré devotes a special chapter to the means of repairing or supplying natural or accidental defects in the human body. He describes artificial eyes and noses, an artificial tongue, and an artificial palate. At a later period Father Sebastian, a Carmelite monk, made movable arms and hands. In the earlier part of the seventeenth century Peter Lowe, in his "Discourses of the Whole Art of Chirurgery," gives representations of artificial legs. About the middle of the same century Falcinelli, a Florentine surgeon, mentions the use of artificial eyes of silver, gold, and crystal painted in various colors; he also describes artificial ears made of the same metals, and fixed by strings to the head or stitched into the skin with gold or silver wire. Silver noses are said to have been in use at an earlier date.—British Medical Journal.

CONTEMPORARY ELECTRICAL SCIENCE.*

THE RATIO e/m.—R. Reiger has resumed Thomson's work on the ratio of charge to mass in cathode rays of the most widely varying origin. He examined cathode rays proceeding from cathodes of different metals, from hot wires, from hot metallic oxides, from a negatively-charged surface under the influence of ultra-violet light and from radio-active substances, as well as secondary cathode rays, and cathode rays transmitted by thin metallic plates. In addition, he produced cathode rays from glass illuminated by ultra-violet light and cathode rays generated within a gas, as in capillary portions of a vacuum tube, so as to determine whether the rays preserve their characteristics when emitted by an insulator or a gas. The results confirm previous ones in showing that whatever the origin of the rays, the ratio e/m is sensibly the same, only varying within narrow limits with the velocity of the electrons. For a glass plate illuminated by ultra-violet light, and negatively charged by means of a sheet of tinfoil attached to the back of it, the author obtained values for e/m varying from 1.03×10^7 to 1.0×10^7 electromagnetic units, the voltage being varied from 8,000 to 10,000. For "strictional" cathode rays the ratio was found to be 1.32×10^7, and for anode canal rays—i. e., cathode rays transmitted through perforations in the anode—Simon's value of 1.68×10^7 was rediscovered.—R. Reiger, Annalen der Physik, No. 10, 1905.

THE ELECTRIC WIND.—J. R. Januszkiewicz proves by a new experiment that the stream of electrified gas proceeding from a charged fine point is stronger from a negatively-charged point than from a positively-charged point; in other words, that the negative electric wind is the stronger. The experimental answer to this question is complicated by the superposition of the electric and mechanical effects of the discharge, but the author has succeeded in eliminating the former. He attaches an aluminium wire at right angles to a nearly vertical axis. At the end of the wire is a hollow metal ball provided with a point projecting toward another ball. In a state of unchanged equilibrium the balls are a few centimeters apart. When they are oppositely charged, and brought close together, they remain stationary at a small distance apart, the electrical attraction being stronger than the mechanical repulsion due to the wind. On the other hand, when the distance is pushed beyond a certain maximum, they remain further apart, the wind more than counterbalancing the attraction. At certain intermediate distances the result depends upon the charge. When the movable ball and its point are negative there is repulsion, otherwise there is attraction. Hence the negative electric wind is stronger than the positive.—J. R. Januszkiewicz, Physikalische Zeitschrift, September 15, 1905.

DISSOCIATION OF GASES EVOLVED FROM METALS.—Winkelmann and Richardson have shown that when hydrogen diffuses through platinum, the diffusion does not vary regularly with the pressure, and that this phenomenon is probably accompanied by a dissociation of hydrogen molecules. This suggests that in metals like platinum, palladium, and sodium the hydrogen may enter into "solid solution" with the metal, in which case it would be naturally dissociated, and any gas given up by the metal might be given in a state of dissociation. To decide this question, S. Guggenheimer charged these metals electrolytically with hydrogen, and then heated them to a temperature not exceeding 220 deg. C., so that there could be no question of ionization by glowing metals. The heated metals were introduced into a glass vessel containing a zinc dissipation body, and any ionization of the gas evolved was searched for by the rate of discharge. There was no increase of the rate, and therefore no dissociation. But in a high vacuum, positive electricity was evolved freely. At ordinary pressures, moderately-heated metals may be safely employed in experiments on gaseous conductivity.—S. Guggenheimer, Physikalische Zeitschrift, Sept. 15, 1905.

* Compiled by E. E. Fournier d'Albe in the Electrician.

SCIENCE NOTES.

The relative strength of different varieties of wheat grown under similar conditions will follow the order in which the wheats are placed by their content in nitrogen; yet if, as at Rothamsted, an increased nitrogen content in the wheat is brought about by excessive nitrogenous manuring, the product is actually considerably weaker than wheat on the other plots grown under more normal conditions. The manuring, while increasing the nitrogenous matter of the wheat, has probably introduced a new factor in the shape of a more prolonged development resulting in the lack of those final changes in the nature of the wheat proteids which make for strength. This seems to be indicated by the fact that on storage this particular abnormal wheat gradually increases in strength up to the normal, though never to the degree that would be indicated by its nitrogen content.

Dulong and Petit found that the physical property called heat capacity is nearly the same for different atoms, i.e., that the quantity of heat requisite to produce a given rise of temperature does not vary greatly for atomic quantities, for 7 parts of lithium and for 240 parts of uranium. Faraday, in studying the electrical conductivity of electrolytes, e.g, of aqueous solutions of salts, found that the quantity of electricity which atoms can transport varies as the whole numbers—from one in potassium to two in zinc. This fundamental property, which gives the sharpest expression to our notion of valency, was brought by Helmholtz into a very clear form by the assumption that electricity as well as matter consists of atoms, either negative or positive, and that material atoms are able to combine with them—potassium with one of the positive kind, zinc with two, chlorine with a negative one—and so transport them in electrolysis.

Apparent Enlargement of the Heavenly Bodies at the Horizon.—It is a fact of current observation that the sun and moon appear greater when they are near the horizon than when they are higher in the sky. Numerous explanations have been proposed to account for this fact. Here is one enunciated by Herr Mayr in the Archiv für die Gesammte Physiologie: When we observe objects at a distance, we have no consciousness of the smallness of the angle under which we see them, and they apear to be higher than they are in reality. It is on this account that there are so many disillusions in photography. A landscape, of which the distant portions are a principal feature, appears nearly flat on the sensitive plate. This is because the objective gives us the real angular sizes of the distant objects, without taking into account the psychical exaggerations of our eyes. If, on the contrary, we look at distant objects under unaccustomed conditions, our judgment is in default. The smallness of the angle of observation becomes sensible, and the object appears much smaller. This happens when we look at a landscape with the head turned toward the side. The colors become more distinct, but the landscape appears flat. This reasoning can be applied to the sun and the moon. When we see these heavenly bodies at the horizon, we instinctively place them at a given distance, and we judge of their size as we do of that of objects situated at that distance; that is, by exaggerating them. But when these luminaries are high in the sky, we see them under unaccustomed conditions, without guiding points, at an indefinable distance; consequently, the exaggerations disappear, and the bodies appear smaller. The angle under which we see the sun or the moon is equal to about half a degree. Calculation shows that this is the angle under which we see a tower 44 meters high at a distance of 5 kilometers, or 88 meters high at a distance of 10 kilometers. Thus, by comparison with known terrestrial objects, the heavenly bodies at the horizon appear to us larger. Besides, the error depends in great part on the state of the atmosphere. It is at the maximum when the sky is clouded and foggy. It then gives to the moon a reddish tint, while, when this luminary appears in its full brilliancy, it differs too much from accustomed terrestrial objects to allow of the instinctive comparison. It then appears to us smaller. The same reasoning applies *à fortiori* to the sun. In foggy weather the celestial bodies appear nearer, which seems to result from their reddish tint, red requiring a greater effort of accommodation to collect on the retina its slightly refrangible radiations. Besides, it is not necessary that there should be terrestrial objects with which we may directly compare the apparent diameter of the sun or of the moon. The error is in the same direction as for terrestrial objects situated at the horizon, but it is produced also in the absence of points of comparison; for example, on a sea horizon. It is to be noted that the constellations undergo the same apparent enlargement on approaching the horizon, and that often the two extremities of the rainbow appear enlarged. In fact, it is a general phenomenon applicable to terrestrial objects as well as to the celestial. In both cases the error consists in an exaggerated estimation of the size of objects situated at the horizon.

ENGINEERING NOTES.

Bridges of monumental nature have generally not received the same careful attention in this country as in Europe. There is really not much difference between public buildings and other public works of like importance. While public buildings have been designed for appearance as well as for permanency, public bridges have been notoriously neglected in both respects. Thus in large cities we see many bridges, which are far from being ornamental or sightly in appearance, situated in prominent places and in public parks in the midst of beautiful landscapes. Such structures, which are in many cases the most prominent objects in a city, should be monumental in character, and designed on æsthetic as well as on engineering principles. Fortunately, in later years, there has been a manifest tendency toward improvement in this direction.

Lubrication has of late formed the subject of important improvements in gas-engines. In engines of medium power, i. e., up to 150 to 200 horse-power, the main bearings of the crank-shaft are usually lubricated by means of a revolving ring plunging in an oil bath. For larger engines bearings with brasses consisting of several parts, to take up the wear and the working stresses, are used. As this system renders it impossible to apply the lubricating ring which gives such good results in dynamos, recourse has been had to continuous oil-feed under pressure. This pressure also secures a more reliable lubrication of large surfaces supporting great loads, as is the case with the crank-shafts of engines of 1,500 to 3,000 horse-power which exceed 500 millimeters (1 foot 7 11/16 inches) diameter. For lubrication of the pistons and the stuffing boxes of the piston-rods, oil-feed under pressure is a necessity, as the oil is more reliably conveyed to the rings, the tightness of which depends to a great extent on the free play secured to them by proper lubrication. Excess of oil in the cylinders which, by rendering them dirty, is the principal cause of "back firing," has also been greatly reduced by the use of a draining device to the cylinder.

Nickel-Steel.—A communication on "Temporary and Permanent Changes in Nickel-Steel" was recently made to the Paris Academy by Ch. Ed. Guilleaume, and was reported in detail by the Hannoversches Gewerbeblatt. The latest experiments on certain alloys of nickel have in general confirmed the results already known, viz., that expansibility possessed by these substances as shown by figures is extraordinarily small, and that therefore these alloys are specially adapted for precise measuring instruments; but at the same time they have rendered possible a more exact determination of the changes which take place in them at the temperature of the surrounding atmosphere. The alterations in length were measured on a rod exposed to a steam bath of 150 to 40 deg. C., and afterward, from March 31, 1897, kept at the temperature of the laboratory (15 deg. C.). At prolonged intervals it was compared with the standard measure of the International Bureau, showing the following results:

Time during which the rod was kept at the temperature of the surrounding atmosphere.	Total increase in length since the exposure to the steam. ($1\mu = 0.001$ min.)
740 days.	7.5μ.
784 days.	7.5μ.
1097 days.	8.6μ.
1347 days.	10.5μ.
2032 days.	11.5μ.

The last expansion observed only amounted to 1μ in about two years.

In the Proceedings of the Société Industrie Minérale we find an account of the behavior of a boiler using different kinds of water, which shows that care must be taken in changing over from one kind to another. The boiler in question, which is of the semi-tubular pattern, had been used with a water giving a great amount of incrustation. On account of the damage caused by the latter purified water was substituted, but it was found that the boiler continued to be burned in some places. This was found to be due to the fact that the deposit which was formed during the use of the incrusting water around the fire tubes, scaled off under the action of the pure water and fell down onto the fire plate, thus causing the latter to be attacked by the fire and swell up in some places. To remedy this action they placed in each of the boilers small shallow trays of sheet iron about 8 feet long and in two pieces, so as to pass through the manhole. These pieces are fixed at a distance of 10 inches above the fire plate and thus receive any of the scale which may fall down from the tubes. After applying this device no more trouble was experienced from the boilers.

Only three conditions are necessary for complete combustion—the proper temperature, the proper air supply, a thorough mixing of the air and the hydrocarbons. The last condition is as important as any and is one too often neglected. It is this condition which gives the gas or liquid hydrocarbon an advantage over the solid, since the atomizing of the former by the steam or air jet insures the most intimate contact between the air and the fuel. The use of pulverized coal in combination with air or steam is a close approximation to the above, and, when properly managed, gives good combustion, no smoke and a high efficiency. The cost of pulverizing and the impracticability of storing pulverized fuel have so far hindered the more general adoption of this process except for metallurgical work.

ELECTRICAL NOTES.

Manufacture of Auer Osmium Lamps.—The Praktische Maschinen-Konstrukteur publishes a summary of facts relating to the production of osmium electric lamps on the Auer system. These lamps are advantageous on account of their limited consumption. The osmium is wrapped in a paste of organic substances not designated. It is passed through a drawplate to obtain filaments, which are rolled on spools and heated out of air in such a way as to produce the desired degree of carbonization for the substances forming the exterior of the filaments. These are placed in moist air, charged with reducing gases and fed by the passage of the electric current. This operation is repeated several times. After the operations of gaging, verification, etc., the filaments are mounted on platinum, placed in bulbs, and a vacuum produced. Finally, the lamps are tested in the photometric laboratory.

The voltage of these lamps was at first quite limited. They are now usually made for 70 to 75 volts (three in a system of 220 volts) and even for 110 volts.

The filament of a lamp for 25 to 37 volts has a length of 0.28 meter, and a diameter less than 0.1 millimeter. The consumption is only 1.5 volts per candlepower. The light is agreeable, resembling that of natural light. The normal life of a lamp is from 1,000 to 2,000 hours.

Osmium lamps are especially recommended for small lighting plants. They are made for 2 volts merely.

Researches on Liquid Dielectrics.—M. Gouré de Villemontée has communicated to the Académie des Sciences the results of his experiments designed (1) to ascertain the influence of the duration of the charge; (2) the electrical state of the mass after the charge. Two cylindrical condensers were filled, the first with petroleum, the second with paraffine oil, and provided respectively with Daniell elements and with Gouy elements. Three series of experiments were made.

In the first series the external armature was carried for the calculation to a given potential, the internal armature was connected with the ground for a given time, then the communications of the internal armature with the electrometer and of the external armature with the ground were established quickly, and the charge of the internal armature measured.

In the second series the charge taken by the internal armature was measured, while keeping the external armature at a given potential, and the internal armature in communication with an electrometer for a determined time.

In the third series the investigator sought to ascertain whether the dielectric was charged through its mass after a determined duration of the charge.

The charges were estimated by the quantity of electricity necessary on a quartz electric piezometer, either for producing a deviation equal to that determining the charge of the armature considered or for compensating the original charge (zero method).

By comparing the results of the experiments with those obtained by M. J. Curie in his investigation of the conductibility of crystallized bodies, it is seen that the propagation of electric charges through petroleum and paraffine oil is comparable with the propagation of electric charges through crystallized bodies.

A similar analogy has been observed by Hertz between the properties of benzine and those of crystals.

Influence of the Chemical Composition of Plate Iron and Cast Steel on Their Magnetic and Electrical Properties.—Researches have been conducted at the Stockholm laboratory of M. Gunnar-Dilner and A. Enström with the following results. The tests were operated with the Dubois balance and a magnetometer. Bars of steel 0.798 centimeter in diameter (0.5 square centimeter in section) and 25.4 centimeters in length, were cut up into blocks. For the plate iron tests, sheets 33 centimeters in length and 0.707 centimeter in width were employed; these were so arranged that the parcel had a total thickness of 0.707 centimeter. Up to 0.5 per cent of carbon the coercive force and the coefficient of hysteresis of the plate iron increase in nearly the proportion of the percentage of carbon. A higher percentage of carbon increases the electric resistance, but has no influence on the hysteresis. If the sample contains silica, the coercive force and the hysteresis increase, as well as the electric resistance, but the maximum induction is not influenced. Silicated iron is, therefore, not suitable for dynamos. For cast steel the permeability and the maximum induction are not influenced by the percentage in silicium. An addition of aluminium diminishes the hysteresis and increases the electric resistance. It is true that, for steel in particular, the maximum induction diminishes also, as well as the permeability. The addition of aluminium is, therefore, to be recommended only for plate iron. For steel the tests have shown that a good result is secured by the simultaneous addition of silicium and aluminium; the hysteresis is diminished, but the induction and permeability are not varied. By heating bars of steel to redness the hysteresis is not diminished. Parcels of plate iron carried to a red heat manifest a coercive force and induction 10 per cent higher on the borders than at the middle, probably because the borders are more highly heated.

With respect to the influence of the mode of production the tests have shown that from the view point of the magnetic qualities, the Bessemer steel is not as good as the Siemens-Martin. The steel prepared by the basic process has also the advantage over that of the acid process, for the percentage in silicium and manganese is less.—L'Etincelle Electrique.

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